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HOUSE OF LORDS

SESSION 1990–91
1st REPORT

SELECT COMMITTEE ON SCIENCE AND TECHNOLOGY

INNOVATION IN MANUFACTURING INDUSTRY

VOLUME III—WRITTEN EVIDENCE

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Memorandum by the Agricultural and Food Research Council

SUMMARY OF MAIN POINTS

1. The AFRC has effective mechanisms for the transfer of technology resulting from work supported in its institutes and in HEIs to manufacturing industry.
2. The protection afforded by patent law encourages investment in contract R&D with AFRC and also encourages the take up by the private sector of intellectual property rights.
3. The involvement of UK research organisations in EC-supported programmes on innovation and technology transfer is generally satisfactory.

INTRODUCTION

The AFRC supports exciting and innovative research aimed at providing the base of scientific enabling technologies which are essential for the UK's international competitiveness. While AFRC does not use Science Budget funds to support research whose primary aim is the development of specific products or processes for near-term commercial advantage, there are areas of basic and strategic research which are exploitable. In the Council's institutes, an increased proportion of funding for applied research comes from industry, and both the researchers and the industrial partners share the task of identifying innovative ideas that can lead to future economic benefit. The industrial relevance of research supported by the AFRC is outlined in the Council's Corporate Plan and summarised in Annex I. Examples involving the manufacturing industries include generating the knowledge base to produce new pharmaceuticals, expanding the potential for non-polluting methods of crop protection and using new approaches in biotechnology and process sciences to improve food safety and quality. In the longer term AFRC research in basic biology is likely to lead to discoveries that alter radically the production processes in, e.g., the pharmaceutical industry. Advances have already been made through techniques of genetic modification towards producing pharmaceuticals in sheep's milk and in plants such as sugar beet. It is against this background that AFRC presents its views on the pursuit of innovation in the manufacturing industry under the Sub Committee's headings 2, 4, 6, 7 and 8.

Q2 *How active are UK companies in seeking out external technology, especially from overseas? How well do they adapt and apply it?*

In fields such as agrochemicals and veterinary products, UK-based companies seem active in acquiring, developing or initiating new technology. Major companies can move rapidly if they consider the potential reward worthwhile. For example, development of the world's first vaccine against Marek's disease in poultry at the AFRC Institute of Animal Health evoked considerable commercial interest. On the other hand, improvements to existing disease control methods met with a slower response. The enthusiasm of UK-based companies in other research areas supported by the AFRC can be variable and although they are often receptive to ideas generated within institutes the initiative almost invariably comes from the institute side.

Q4 *How effective are the activities of Government departments in promoting and supporting innovation?*

DES Science Budget allocations to the AFRC support the creation and maintenance of an innovative science base. Such a base is a major means of generating ideas capable of exploitation by industry. The DTI-LINK scheme is one element in this process. However, the recent Government withdrawal from near-market research (which affects AFRC through MAFF commissioning) may have adverse implications for technology transfer and the exploitation of innovation. Where pre-competitive studies are required before ideas are taken up and utilised, there are now the responsibility of industry to develop arrangements to fill this gap.

Q6 *What is the effect of the legislative and regulatory framework concerning for example labour costs, patent laws and tax concessions on R&D and the purchase of know-how?*

Patent law has a direct effect on R&D and the purchase of know-how. The monopoly granted by patent law is designed to foster industry and commerce within a secure and disciplined framework. By conferring patent rights for a reasonable period of time, they encourage inventors and industry to take on the risks of breaking new ground and, by insisting that details of inventions are made public, they stimulate the rapid spread of technological knowledge.

The protection afforded by patent law encourages investment in contract R&D with AFRC and also encourages the take-up by the private sector of intellectual property rights (IPR) and know-how arising from the Council's own programmes. Over the last five years AFRC has tripled its contract income from £5 million to £15 million, with over half coming from the industrial sector. During 1988-89 AFRC undertook research for 316 organisations, of which 157 were direct contracts with private companies. Most of these arrangements involve a degree of exclusivity based on patent protection.

The most successful example of the use of the patent system in recent times is the protection of the results of the AFRC Institute of Arable Crops Research's programme on pyrethrin analogue insecticides with a portfolio of more than 500 separate patents involving 34 basic inventions. This portfolio is British Technology Group's (BTG) second biggest income generator.

AFRC is monitoring the progress of a number of legal changes which are currently being proposed. These include:

- The new Food Bill which will reflect the very high level of consumer interest in matters such as food safety and quality. The effect of regulations that may arise from this bill are as yet unclear but they could have an impact on the exploitation of biological systems by UK agricultural and food companies.
- The proposed EC Directive on the legal protection of biotechnological inventions which is welcomed by Council. The authoritative guidance which should emerge on the protection of genetically-engineered plant and animal life forms should further encourage take-up of AFRC know-how in this area.
- The proposed harmonisation of patent law and plant breeders rights within Member States.

Q7 *How effective are the mechanisms for technology transfer from HEIs, Research Councils and public laboratories to manufacturing industry?*

In 1985 the Secretary of State for Education and Science announced new arrangements for the exploitation of government-funded research. This followed the earlier announcement by the Prime Minister of the ending of the rights of first refusal to inventions enjoyed by BTG. In essence this meant that, in the university support area, Research Councils were directed to allow ownership of IPR to remain with the universities concerned, together with responsibility for exploitation and income so derived. Similarly, Research Councils would be responsible for IPR, technology transfer and exploitation arising at their own institutes.

TECHNOLOGY TRANSFER—AFRC INSTITUTES

Within AFRC the traditional route for technology transfer has been through the Agricultural Development and Advisory Service (ADAS) of the Ministry of Agriculture, Fisheries and Food (MAFF). ADAS has increasingly close links with AFRC and in exercising two of its principal functions, namely the provision of advice to farmers and growers to help them develop financially sound businesses and to identify problems requiring investigation and solution, it both stimulates agricultural R&D and helps disseminate research findings directly into practical agriculture.

An increasingly important route for AFRC is by industrial contracts and by direct contact with the commercial world, including venture capital companies, British Technology Group, etc. AFRC adopts a flexible, case by case, approach to exploitation with the primary aim of achieving the most appropriate, efficient and cost effective route. The underlying philosophy is that AFRC institutes should concentrate on their scientific and technical skills leaving the private sector, as far as possible, responsible for development, testing and marketing and to take the financial risks.

The AFRC is also actively involved in the Government's LINK scheme. The Council injects funds as a programme sponsor and AFRC institutes undertake projects as research partners. The Council considers LINK to be a useful aid to technology transfer and a means of breaking down barriers between academia and industry. In AFRC's experience it is a particularly successful scheme when the relationship is with one or two companies rather than large consortia. In some areas, however, industry has experienced difficulties adjusting to the requirements imposed by the LINK criteria: a flexible approach is needed to maximise the creative interaction of industrial companies with HEI's and Research Councils.

Research on behalf of levy funded bodies is another key element of the AFRC's technology transfer. The existence of the levy body ensures that there is an immediate outlet for research targeted to, for example, a specific crop. An example is the work on sugar beet at the Broom's Barn Experimental Station, part of the AFRC Institute of Arable Crops Research, which exemplifies the way in which technology has been transferred to industry, resulting in more efficient production and manufacturing of the product. Work on seed pelleting, aphid monitoring, weed beet and its control, and yield prediction, has been applied efficiently and rapidly because of the co-ordination by the Sugar Beet Research and Education Committee and the fact that the work has been targeted towards a single crop.

The various mechanisms for technology transfer are already effective but will become even more so as expertise in this area increases. AFRC set up a Commercial Policy Unit in 1986 to establish procedures and co-ordinate activities. Research leaders and senior management at institutes attach considerable importance to technology transfer and exploitation. Marketing managers are now being appointed for individual institutes.

TECHNOLOGY TRANSFER—HEIs

Research Councils have adopted a common approach, by means of an Inter-Research Council Exploitation Scrutiny Group, to the transfer of and responsibility for exploitation to universities and other higher education institutions. These arrangements allow universities to retain the IPR and any income from exploitation arising from AFRC research grants.

The Universities provide annual reports to the Scrutiny Group on the exploitation of discoveries and this monitoring and review mechanism allows the Research Councils to assess the success of the arrangements in use and if necessary suggest revisions or amendments to these. To date these arrangements are working well and AFRC has no plans to change them.

OTHER TECHNOLOGY TRANSFER ROUTES INCLUDE:

(i) Publication in scientific and popular journals.
(ii) Written or oral presentations at national and international meetings.
(iii) Close association with the farming community by means of Institute Open Days and Subject Days; and through Members and Friends Associations.
(iv) Training, sandwich-course and co-operative (AFRC/industry) research studentships.

Q8 *Does the UK benefit sufficiently from EC support for innovation? How might it be improved?*
The AFRC supports basic and strategic research in the biological and related sciences and "innovation" defined as the application of new knowledge takes place downstream of the EC supported programmes in which AFRC is most closely involved. EC support for innovation is located primarily in the Strategic Programme for Innovation and Technology Transfer (SPRINT). We understand that the SPRINT programme (located in Directorate General XIII) has been reasonably successful in promoting linkages between the pre-competitive stage of research and the innovation stage. The UK is well represented in the SPRINT-generated Transnational Technology Transfer Networks. As part of SPRINT, the Commission is developing a comprehensive database of organisations supporting innovation in Europe, and the Second European Technology Transfer and Innovation Opportunities Exhibition and Conference will be held in Glasgow on 22-24 May 1990.

Improvements in EC support for innovation may be achieved in the future, through the new Valorisation and Utilisation for Europe (VALUE) programme to promote the dissemination and utilisation of the results of scientific and technical research; and by the likely increase in SPRINT activity. The involvement of UK research organisations in these programmes is generally satisfactory, but the manufacturing sector may need further encouragement to ensure that it uses the information and networks available via SPRINT.

EC is increasingly encouraging the use of the European Research and Co-ordination Agency (EUREKA) for technology transfer. There has been little AFRC involvement in EUREKA since this programme operates very close to the market place and is aimed at new product and process development. AFRC Institutes are not eligible for direct funding through EUREKA but can be a sub-contractor for one of the industrial partners.

Agricultural and Food Research Council
April 1990

ANNEX I

INDUSTRIAL RELEVANCE OF RESEARCH AT AFRC'S INSTITUTES

Plant Science

Generation of the knowledge base to produce improved crop varieties for plant breeders, including disease resistant varieties, new pharmaceuticals and other bio-active compounds of agricultural and agro-industrial importance, improved non-food products such as fibres and chemical feedstocks, and exploit further the nitrogen fixation processes; to generate commercially important plants capable of growth in extreme environments.

Arable Crops

To increase the efficiency and product quality of UK farming and provide a basis for better management of the husbandry of crops. To achieve good agronomic practice for new and existing arable crops and expand the potential for non-polluting methods of crop protection in Britain and abroad.

Horticulture

To enhance the competitiveness of the UK horticultural industry by providing a basis for improving crop quality, extending the growing season and developing environmentally-sensitive methods of crops management and pest and disease control that aim to reduce agrochemical inputs.

Engineering

To provide more efficient methods, with cost benefits to industry from improved product quality and reduced input costs; whilst safeguarding the environment and improving the health and welfare of workers and livestock. To prove the feasibility of scaling up biotechnological discoveries and to generate fundamental process engineering data.

Grassland and the Environment

To provide environmentally acceptable options for sustaining production from grassland and for alternative land use, by improving plant breeding methodology and exploiting new sources of genetic variation. To provide principles for improving nutritional efficiency and predictability in livestock. To develop immunological and microbiological tools for enhancing meat and milk production and quality.

Animal Physiology and Genetics

To apply the discoveries in embryo manipulation, gene transfer and expression, and the molecular identification of performance traits to livestock improvement. To use knowledge of how internal and external signals influence brain function in providing for an animal's wellbeing within its environment.

Animal Health

To apply newly acquired knowledge on the diseases of agricultural importance to the development of new or improved methods of diagnosis, control and prevention, and to impove food safety and quality.

Food

To provide a framework for exploitation of these scientific advances, through new approaches in biotechnology, biophysics and process sciences (a) to improve the safety, quality and nutritive value of foods for consumers and (b) to generate and evaluate new options for safe and efficient food manufacture.

Memorandum by the Association of the British Pharmaceutical Industry

SUMMARY

Q1 It is pointed out that the activities of UK pharmaceutical companies are not confined within the shores of the UK. As a result company policies, for example, on investment in research and development are flexible and activities can be situated in locations where the most favourable conditions exist.

The cost of discovering a new medicine is extremely high, on average £100 million. The benefits of investment in R&D of sums of this size to the national economy are readily apparent and it is important that the climate for investment in the UK is such as to encourage pharmaceutical companies to invest here.

Q2 UK companies are active in seeking out external technology which they can use and adapt in compliance with their particular overall strategies. The source of the technology is unimportant, be it found in the UK or overseas.

Q3 The term "product development" has a special meaning in the pharmaceutical industry. The development phase of a medicine is made up of safety and efficacy testing before administration to the patient, and the consequent formulation of the medicine into a form suitable for human administration. It includes also the stage of clinical evaluation.

Q4 The response to this question on the effectiveness of Government departments in promoting and supporting innovation has been broken down into observations on each of the relevant departments separately. Brief comments are set out below.

The Department of Trade and Industry is praised for its support in amending the provisions in the Patents Act 1977 whereby, originally, licences of right were automatically available on pharmaceutical patents during the last four years (16-20 years inclusive) of a patent's life. Additionally, the Department has been largely supportive of the EC initiative to restore the patent term of pharmaceutical patents, i.e., to restore some of the patent period lost while a product passes through the regulatory process, often as much as 8-12 years. Patent term restoration is absolutely fundamental to the future health of the UK pharmaceutical industry.

It is felt that the sponsorship role of the Department of Health towards the industry has become less effective in promoting and supporting innovation during the last five years. The operation of the Pharmaceutical Price Regulation Scheme (PPRS) has been such that there is less encouragement than formerly for the locating of new technologies in the UK. Government sponsorship of the industry is perceived as being less than that in France and Italy, for example.

Insofar as the Department of Education and Science is concerned, the industry has noted the apparent drift away from science subjects in schools. There is also a concurrent shortage of science teachers and there will, as a result, be fewer science graduates of high quality available to UK industry in the future. Good science graduates are the life blood of the pharmaceutical industry. There is also concern about the low level of funding for postgraduate students, a factor which will mitigate against the best graduates undertaking research. The Association has produced a report on skills shortage in the industry, which is annexed to the full submission.

The attitude of certain Inland Revenue inspectors to the financing of R&D is causing concern to some companies. Some inspectors are seeking to re-define R&D, splitting research from development with the result that tax relief on capital spent on development will not be available. In their activities the inspectors are seeking to limit the scope of the statutory definition of scientific research, something which only Parliament has the right to do.

Q5 The views of the city *vis a vis* the industry are thought to be "short termist". Pharmaceutical medicines often have a long lead time before marketing, up to 10-12 years and short-term views are contrary to the industry's interest.

Q6 Good and equitable patent laws are vital to the interests of the industry. As has been stated previously, the principle of patent term restoration is of the utmost importance, particularly as legislation has already been introduced in the USA and Japan to restore lost term in respect of pharmaceutical patents.

Q7 It is considered, by and large, that the mechanisms for technology transfer from HEIs, Research Councils, etc., are by no means satisfactory and at best can be described as in need of improvement.

Q8 The general conception is that the UK pharmaceutical industry does not benefit greatly from EC support for innovation and that where initiatives are available the Government is often slow to promote UK interests.

Q9 The relevance of this question to the industry is difficult to interpret.

Q10 A list of factors influencing decisions to invest in innovation is set out in the full submission, not the least of which are company profitability, active Government support for the industry, better intellectual property protection and a continuing supply of high quality scientists being available to the industry.

Q11 It is considered that the relationship between the defence and pharmaceutical industries is far from satisfactory, to the detriment of the interests of both the country and the industry.

Q1 *What are the effects of company attitudes and structures (including personnel policies, investment decisions)?*
In general, most of the UK pharmaceutical companies' activities are not restricted within the shores of the UK and they are obliged to operate as multi-national companies in order to prosper. That being the case, they are able to programme their activities so that they are carried out wherever the optimal conditions exist and this may not be the UK.

Innovation in the pharmaceutical industry requires substantial investment. For example, the cost of discovering a New Chemical Entity and processing it to the stage of obtaining marketing authorisation costs on average 100 million pounds. It is considered that the climate for investment in the UK, and therefore innovation in the UK, is not as promising as it was. This is evidenced by the fact that several large-scale, UK based pharmaceutical companies are strengthening their operations abroad. Similarly, international, non-UK companies are becoming more tentative about investment in the UK.

Across the Atlantic, particularly, it is perceived that the Government does not give sufficient regard to the very positive balance of trade contributed by the pharmaceutical industry in the UK. As a result there could well be a re-appraisal of this country as a research base with the possibility of projects being placed elsewhere. It is unlikely that there will be reduction of R&D in the pharmaceutical industry globally. What companies will do however, is to position their research facilities where the scinetific, financial and other climates best suit them.

What are considered to be obstacles to investment include possible developments in relation to the National Health Service (NHS)—GP budgets, the development of formularies (lists of recommended medicines to be prescribed), the active encouragement by government of the use of generic medicines, etc. Another example of that which constitutes an obstacle to investment would be the government's attitude to universities and hospitals. Increasingly they are being required to supplement the inadequate funding received from the government by, for example, increasing charges for services provided. As a result costs to the pharmaceutical industry for work carried out in connection with clinical trials, for example, have been raised significantly.

Government policies in relation to education, particularly in the university sector, are also of concern to the industry. Diminishing numbers of students are taking science courses and while the best graduates and post-graduate students compare favourably with their predecessors the proportion of quality students is declining. The problems, mainly of a financial nature, posed to post-graduates intent upon pursuing research training are of enormous concern. High quality graduates and post-graduates are essential in an industry as dependent on research as is the pharmaceutical industry, but in the UK the numbers of such personnel available to the industry appear to be falling.

Q2 *How active are the UK companies in seeking out external technology, especially from overseas? How well do they adapt and apply it?*
The UK pharmaceutical companies operate as multinationals with continuous contact with scientific and other technological resources throughout the world. They both licence in and licence out products and technologies. While the UK industry leads the world in pharmaceutical research it imports "technology" in the form of production machinery from Europe and, more recently, from Japan. The UK engineering industry lags in this particular area. Similarly laboratory equipment has to be bought in, particularly from Japan.

The phrase "adapt and apply" does not lend itself readily to the activities of pharmaceutical companies. Given that a company discovers a novel compound, its strategy will be to take that compound through the necessary stages of development so that marketing authorisation is received worldwide in as short a time as possible.

One of the keys to achieving rapid authorisation for a new medicine is a regulatory process which, while being stringent in the interests of the safety of the public, should nevertheless be flexible, efficient and not bogged down by bureaucracy. The industry considers that while the UK registration system by no means compares unfavourably with those in other European countries, it is, nevertheless, capable of being improved.

Q3 *What are the respective roles played by product development and production engineering in technological innovation?*
Basic research in the development of new medicines involves investigation into the fundamental processes of physiology and pathology and will usually involve the development of a variety of new techniques. Applied research is the development of specific new chemical entities (NCEs) to influence these processes. The development phase of a medicine is made up of the safety and efficacy testing of the new chemical before it enters the patient and the pharmaceutical formulation of the NCE into a form where it is suitable to be administered to man. There then follows the stage of clinical evaluation. New formulations and new routes of administration can involve research into new delivery systems, perhaps making them safer or giving them greater efficacy via better defined distribution through specific body systems.

Q4 *How effective are the activities of Government departments in promoting and supporting innovation?*
Oblique reference to some government departments has been made in dealing with earlier questions in this paper.

(1) The Department of Trade and Industry (DTI)

The DTI has recently shown active support for the pharmaceutical industry. The Copyright, Designs and Patents Act 1988 effectively repealed, for the industry, the licence of right provisions in the 1977 Patents Act whereby a patent was subject to a mandatory licence during its last four years (i.e., from year 16 onwards). Further, the Department seems supportive of the intention of the European Commission to introduce patent term restoration (PTR). The proposal allows recovery of some of the years lost to a pharmaceutical patent during the regulatory process, i.e., before marketing authorisation is obtained. Both the removal of licences of right and patent term restoration are of the utmost importance to the industry and are likely to result in increased innovative activity. Research can only be funded out of sales and tomorrow's research very much depends on the receipt of adequate returns from the sale of today's medicines.

The DTI is also responsible for the introduction of the LINK programmes. The programmes are splendid in conception intending to encourage pre-competitive, industrially relevant, research projects involving higher education institutions and industry jointly. They have, however, been stifled by bureaucracy and the transition from programmes to projects has not been as productive as might have been hoped. While some of the projects have been adopted by the pharmaceutical industry, the suitability of others for industrial development has been doubtful.

The industry notes the recent publication of the DTI/Council for Industry and Higher Education booklet entitled "Research and Development". The aim of improving collaboration between industry in general and higher education in areas of research is one which the UK pharmaceutical industry would support.

(i) The Department of Health (DoH)

In the build up to the mid-1980s the sponsorship role of the Department of Health towards the pharmaceutical industry was reasonably effective in promoting and supporting innovation. In particular, companies were encouraged by relatively favourable treatment under the Pharmaceutical Price Regulation Scheme (PPRS) to site new technologies in the UK and to invest in research and development facilities. To the extent that research costs in the UK are lower than the US and some other European countries, there is still an inclination by some companies to expand their UK operations.

However, since the mid-1980s the sponsorship role of the Department of Health has become progressively more diluted and is now virtually non-existent compared with European competitor countries such as France and Italy. The situation is likely to become progressively worse with the implementation of the proposals in the National Health Service and Community Care Bill and the stated policy of the Government to put downward pressure on the medicines bill, even though several assurances have been given that patients will continue to receive the medicines they need. UK market prices are used as reference prices by many other countries and this downward pressure on prices is likely to have a material impact on companies' perception of the UK as a base for investment.

As stated, the industry is extremely concerned about the possible effect on innovation of the National Health Service and Community Care Bill, currently passing through Parliament. The introduction of both practice budgets and indicative drug budgets for general practitioners could have the effect of doctors not prescribing new innovative medicines for their patients. Such medicines may well be more expensive than those which they supercede. Companies fear, therefore, a lower return on their R&D investment and consequently a smaller purse out of which to fund subsequent research.

Any development in the production of formularies would also be seen as an instrument which could stifle innovation. Two questions arise, firstly will the higher-cost, newly developed, medicines find their place in formularies and secondly, when a formulary has been introduced, how quickly would a subsequently licensed product get on to it? Formularies are seen by the industry as a means to maintain the *status quo* and to keep down expense, possibly to the detriment of the patient.

Moreover it has been shown that the use of new, and admittedly often more expensive medicines, can in the long-term reduce total health-care costs. Beta blockers and the H2 antagonists are good examples of such products. The formula of an increased return on investment for the manufacturer, in turn stimulating increased innovation, while reducing the costs of treatment must be one which appeals to any government.

The UK-based pharmaceutical industry has been singularly effective in producing major fundamental advances in therapy. The three most widely used medicines in the world are the products of British research as are 11 of the top 50. However, as well as major strides forward in therapy, progress may also be made in small incremental steps and these are not to be despised.

(iii) The Foreign Office

The Foreign Office should be made more aware of the international nature of the industry and therefore of the industry's requirements in the international field. Support to the industry analagous to that given to its US equivalent by the US Department of Trade and Industry would be welcome. Often the industry feels disadvantaged by decisions taken by foreign governments and it is at such times that the relevant British Embassies should provide the support which the industry needs, often at short notice. An example of a situation in which help is sometimes required is in the area of intellectual property rights. Inadequate intellectual property protection in countries such as Brazil, India and South Korea costs British companies millions of pounds and reduces the size of the pool out of which research is funded. The UK government should be seen to be supporting industry by applying pressure where necessary and also by ensuring international agreements carry the necessary teeth to put a stop to the activities of pirate nations.

(iv) The Department of Education and Science

The British-based pharmaceutical industry spends £750 million per year on research compared with £350 million by the Medical Research Council and research charities. Although the industry finances its own research programme, it nevertheless is concerned that government funding for research available to the councils is increasing only minimally. When increases in the costs of salaries, equipment and the like are taken into account, effectively the funding in real terms must be reducing. The industry is concerned that the Department is failing to respond to the rate at which the scientific world is moving and the increasing costs required to fund this progress effectively.

The matter of education is also one of concern to the industry. The available figures demonstrate that fewer children are taking science in secondary schools and as a result there are fewer undergraduates in science. The pharmaceutical industry depends absolutely on its ability to recruit first class scientists both at graduate and postgraduate level. To a large extent, the reason why, historically, so much innovation in the industry has come out of the UK is that there has always been available pool of high quality scientists. There is a danger that this pool is getting smaller.

Another concern with issues at university level is that there is currently a fashion for mixed science degrees, e.g., science and management, science and law. Such degrees are of limited use to the pharmaceutical industry. What the industry needs to further its research are scientists well trained in a single discipline, e.g., chemists, biochemists, pharmacologists, etc.

The Association has commissioned a report entitled "Skills Shortage in Pharmaceutical Industry Research and Development" by Dr T I Wrigley, a copy of which is annexed hereto.

(v) The Department of Employment (The Health and Safety Executive)

There have been recent developments in relation to the HSE which have affected the industry. The Control of Substances Hazardous to Health (COSHH) Regulations have recently been implemented as has the European Directive on the Classification, Packaging and Labelling of Dangerous Substances. Insofar as the Directive is concerned, it is deemed that pharmaceutical intermediate products are caught by it. As a result such substances cannot be transported without notification of their toxicity profiles to the HSE. Supplying such a profile will require substantial scientific investigation, including testing in animals. The legislation imposes additional costs on the industry which, although not in themselves significant, indicate further the increasing demands on the amount of capital available for innovation.

(vi) The Inland Revenue

Pharmaceutical companies' expenditure on R&D is financed both out of revenue and out of capital. Insofar as financing R&D out of revenue is concerned, no problems arise from the point of view of taxation. With capital expenditure, the tax position is very complicated. For some considerable time the whole of a company's capital expenditure on R&D has been allowed to be written off in the year in which it occurred. This arrangement has been conducive to the carrying out of research in the UK. There has been no suggestion by Government that this arrangement should be changed. However, local inland revenue inspectors are seeking to re-define R&D, splitting research from development. If the process is allowed to continue, tax relief on capital spent on development will not be available. The local inspectors are effectively saying that research is complete when a company has produced a medically active compound without regard to the need to prove that it is safe and effective. (See the response to question 3 which clearly indicates that safety and efficacy form part of product development).

The definition of scientific research in the relevant statute is very wide—". . . any activities in the field of natural or applied science for the extension of knowledge". It would appear that the Inland Revenue inspectors, in their efforts to collect more tax, are restricting the scope of this definition—something which should be carried out only by Parliament.

Q5 *What are the effects of city attitudes to investment in innovation?*

A strongly held view in the industry is that the city is "short-termist" in its views, i.e., it has a poor perception of the time taken between discovery of a medicine and its being available on the market, a period often as long as 10 to 12 years, during which there may be two or three changes of government.

There would also seem to be a view in the city that biotechnology holds the key to the solution of many medical problems and there is a perceived eagerness to invest in biotechnological companies. While it is agreed that biotechnology is important, it would be more rational for the city to spread its investments more widely across the scientific spectrum. The reality is that biotechnology occupies a relatively small segment of research and the city should make a wider appraisal of scientific research as it applies to the pharmaceutical industry.

The stock market view of the industry sometimes appears to be superficial, if not sensationalist. A lack of confidence in future market prospects often based upon subjective reports can have a severely adverse effect on a company, for example by reducing its ability to raise capital or by rendering it subject to a take over. Such a lack of confidence can adversely affect a company's research policy.

Q6 *What is the effect of the legislative and regulatory framework concerning, for example, labour costs, patent laws and tax concessions on R&D and the purchase of know-how?*

Labour costs do not adversely affect the UK pharmaceutical industry being, as they are, lower than in many of the countries considered to be competitors, e.g., Germany, Switzerland and the USA. In fact, lower labour costs encourage foreign investment in research and development in the UK. (The other side of the coin is that they may lead to a "brain drain").

Dealing with the issue of patent laws, it is important for the future health of R&D in the industry that the EC proposal for patent term restoration is strongly supported by HM Government. As previously stated, because of the regulatory requirements, as much as 12 years of a product's patent life are lost before marketing authorisation is obtained. This means that effective patent life, the period during which the investment in R&D on that product can be recovered, is of the order of eight years. Already Japan and the USA, two of the UK industry's biggest competitors, have taken steps to restore lost patent term and have introduced a period of restoration, giving them a considerable advantage over the UK.

There is growing concern at the unreasonably wide breadth of patent claims being granted by the European Patent Office in the area of biotechnology. The grant of such patents precludes research being carried out by competitor companies in the patented areas. As the UK has a leading role in biotechnology research, the effect of the broad based patents is to damp down innovation in this country. The Government should be aware of the problem and should support the view of the UK industry in discussions with its European partners.

The Patents Act 1977 contains two provisions which the UK industry would like to see repealed—the Crown Use provisions and also the provision for the granting of compulsory licences against the patentee. The Crown Use provisions should be retained only insofar as they are necessary for defence of the realm. With regard to compulsory licences, working a patent in any EC country should be considered as working that patent in the UK.

The Animals (Scientific Procedures) Act 1986, although making conditions under which animal experimentation can be conducted more stringent, in fact imposed standards which, almost uniformly, were already applied in the industry. However, it imposed standards which were very costly for universities and other bodies, such as the Medical Research Council, to comply with. This must have had an impact on the money available for academic research and an indirect "knock-on" effect on the scientific environment.

Reference has already been made, in response to question 4, to the influence of the Pharmaceutical Price Regulation Scheme.

Q7 *How effective are the mechanisms for technology transfer from HEIs, Research Councils and public laboratories to manufacturing industry?*

The industry believes technology transfer to be a very hit and miss affair. Generally technology transfer is carried out by scientists watching the literature, having personal contacts, attending scientific meetings, etc. An attempt by the Government to ensure that technology was transferred on appropriate terms, i.e., to the benefit of the researcher, the receiving company and the country was made via the British Technology Group (BTG). However, University departments took decisions, in many cases, to appoint industrial liaison specialists thus by-passing BTG, whose operation was considered to be very slow and bureaucratic. The effect has been that academics now transfer technology direct to industry which means that while there is no longer a uniformly structured form of transfer, the end result is likely to be better for both parties.

With reference to the Medical Research Council (MRC), the record of the transfer of technology from this body to industry has been indifferent at best. The general criticism of the MRC is that its scientists are too single-minded in their approach and thus unprepared to compromise in order to meet industry's needs.

In the patents field, there is an increasing tendency by the organisations referred to in the question to licence rather than assign to companies. The industry believes that this practice should be discouraged as it is believed that the transferrer gains little from the arrangement. Generally a licensing agreement does not lead to full development of the potential of an invention.

Q8 *Does the UK benefit sufficiently from EC support for innovation? How might it be improved?*
The Association does not believe that the UK pharmaceutical industry benefits sufficiently from EC support for innovation. One reason for this is the bureaucracy. Enormous numbers of complicated forms require to be completed in order to apply for support and the task is reported as being overwhelming. Consequently a more "user-friendly" approach by the EC would be advantageous. Secondly, unfortunately UK industry by and large does not know what is available. However, not all the blame for this can be attached to the EC as companies are sometimes slow to help themselves. It would be advantageous if the benefits of EC support were given greater publicity as often they are believed to be worthwhile, providing the system can be penetrated.

It is the view of the industry that where initiatives are available, often the UK Government is slow to promote UK interests. The Commission's support for patent term restoration is an example of a European initiative having the effect of supporting innovation. The UK Government, however, was not amongst the front runners when the initiative was first mooted and it is believed that support for the proposal at the Department of Health is still only luke-warm at best. In view of the industry's contribution to the UK economy, by virtue of its large, positive balance of trade together with taxes paid to the Treasury, both by the companies directly and by their 73,000 employees, it is surprising that the Department has not adopted a more positive stance.

Q9 *What are the effects of the varying relationships between companies and their suppliers?*
The relationship which the industry has with a variety of suppliers, e.g., those supplying raw materials, packaging, production equipment and laboratory equipment for its research laboratories, is complex. In this light, it is difficult to interpret the specific objective of the question.

The pharmaceutical industry, unlike any other industry, has to conduct studies on patients, those studies being controlled by the Medicines Act 1968. They have to be conducted in co-operation with the medical profession and in this context the profession supplies a service, one which is strictly controlled, to the industry in its research role.

Q10 *What factors influence decisions to invest in innovation in the UK or overseas?*
There are many factors taken into account by the pharmaceutical industry, some of the more important of which are listed in order of priority:

(i) Profitability. If the industry is not profitable it will not carry out research.
(ii) The foreseen trends in government policy towards the industry. The encouragement of generic prescribing, the use of formularies and other attempts to encourage the prescribing of cheaper, less sophisticated medicines, all create an atmosphere of doubt about the future prospects of the industry.
(iii) The poor intellectual property protection currently available in Europe compared with both the USA and Japan.
(iv) The Pharmaceutical Price Regulation Scheme (PPRS). It is essential for the government to allow a proper return on investment. With an adequate return, the industry will respond with further investment.
(v) The availability of good quality scientists and technicians reflecting the quality of the educational system and the quality of research carried out at universities.
(vi) Sensible and practical animal welfare legislation, justifiable both on scientific and animal welfare grounds.
(vii) A readiness to embrace new products.
(viii) High standards of health care.
(ix) What other countries are offering by way of inducements.
(x) Monetary stability, i.e., stable interest rates and exchange rates together with low inflation.
(xi) The absence of exchange control.

(xii) Longer-term support from the City.
(xiii) Political stability (overseas).

Q11 *In the light of ACOST's report "Defence R&D: A National Resource", and the Government's response, is there a satisfactory relationship between the defence and civil sectors?*

We have not had the benefit of reading the ACOST report, or the Government's response, but it is the belief of the industry that the relationship between the defence and civil sectors is far from satisfactory and, as a result, opportunities which should be available to industry are being missed. Much of the fundamental research carried out in the name of defence is not made available to the scientific community at large. The loss to UK industry as a result of this policy should be considered. Further, the defence sector often has research facilities which are superior to, or of a type not available to the civil sector because of their specialised nature. When there is spare capacity in such areas the Government's tendency is to cut them back. Industry's view is that these facilities should be contracted out to companies which are not otherwise able to avail themselves of them.

Memorandum by the Association of Independent Research and Technology Organisations

1. AIRTO

AIRTO represents the United Kingdom's independent research and technology organisations (the RTOs) and promotes their role in strengthening our nation's industrial performance through research, development, design and innovative consultancy.

AIRTO provides a single point of contact between the UK independent research and technology organisations and government agencies, industry bodies, and the European Community. It co-ordinates the views of its members and, by representing these to industry and Government in a cohesive manner, strengthens the image, influence and clarity of the research and technology sector in matters of policy and practice.

With more than 40 member companies having between them a total research turnover of over £300 million, AIRTO represents a significant and growing part of the industrial R&D effort of the UK. Members' activities span an extremely wide range of disciplines from life sciences to engineering. Their work includes fundamental research, developing and designing innovative products or processes, instrumentation testing and certification, and technology and management consultancy. Most members run comprehensive information services, conferences and seminars as part of the process of knowledge acquisition and dissemination. Many organise joint ventures and major collaborative projects.

AIRTO's membership is drawn from UK based research and technology organisations having legal, financial and commercial independence, and a proven track record of substance, quality and standing.

2. Background to innovation in the UK

The perception of AIRTO is that there is, in general, no long term vision for the industrial future of the UK; the importance of the manufacturing sector is not emphasised; market forces are believed to be pre-eminent; innovation which requires science and technological base with a long term time span cannot be fostered by the market economy on its own because long term considerations are not determined by the market and hence the market cannot cope with these. The short termism in the City is a factor too. This has been denied by the CBI Task Force but the problem is that ownership in British Industry is dominated by share dealers not share owners.

The result of this lack of long term vision, the market attitude of Government, the short termism in the City, is that innovation in the UK had to be directed towards short term results and this is gradually downgrading the innovative capacity of the country. Short term applications require current day technology. Long term applications require the development of future technology. This country is therefore running down its intellectual technological base very rapidly. A similar erosion has been taking place in the science base of the universities, although this seems to have been recognised recently by a more long term attitude from Government. Perhaps a similar change is required to recognise a need to rebuild and refurbish our long term technological base.

Q1 *What are the effects of company attitudes and structures (including personnel policies, investment decisions)?*

Unless the Chief Executive of a company is committed to innovation, unless the structure of a company emphasises the importance of the customer base and the importance of the skills of the personnel, the company is not likely to encourage innovation. The book "In Search of Excellence" and the recent Innovation Toolkit produced by NEDO, all stress the company qualities required for innovation.

In summary attitudes to innovation are governed by several factors including company culture, the market environment, government policy and the investment requirement of the shareholder, notably the City.

In the UK these factors have all tended to work against investment in innovation. For example, the power generation business was affected adversely by the oil crisis, as well as being cyclic in demand. Of necessity this has led to greater priority being given to short-term financial objectives over the longer-term innovation and development of new products. Whilst the position is improving, so is that of the competition, notably in the USA, Europe and Japan who enjoy a more favourable climate for investment and innovation.

Personal policies, which are based on professional growth and reward for performance and technical achievement, encourage innovation. The move towards organic or cellular organisational structures rather than the traditional hierarchical structure will also stimulate innovation. These changes are, however, only just emerging in UK industry as a whole.

Q2 *How active are UK companies in seeking out external technology, especially from overseas? How well do they adapt and apply it?*

On the whole, UK companies are not active in seeking external technology. The "Not Invented Here" syndrome is very prevalent, except possibly in the small high tech companies. Britain has excelled in science and technology for so long that there is a feeling that we can, and should, do it all ourselves. Hence the will to apply external technology is low in UK industries, and therefore automatically the experience of skill in so doing is low.

Unfortunately UK companies often find themselves in the position where they realise that their existing products are no longer attractive because they have not had sufficient resources to carry through innovation. In order to remedy this deficiency they seek to become a licensee of an external company, either within the UK or overseas. As such the licensing process is carried out from a position of weakness rather than strength. The Licencees concerned neither adapt the technology sufficiently, nor apply it to best advantage. Licencing is not an alternative to having sufficient qualified staff in place to carry through innovation.

Q3 *What are the respective roles played by product development and production engineering in technological innovation?*

Whilst historically product development and production engineering were largely separate activities, experience has shown that this is very expensive in both product development and production costs.

Product development and production engineering are interdependent. Most companies have now integrated these two activities within the product definition process to ensure that the new or improved product meets the market requirements of function, durability and quality at minimum cost. This process should start at the research phase and continue during product development.

Product development is, of course, part of technological innovation, but production engineering is essential for technological innovation to be successful. Here Britain does suffer from severe experience and cultural weaknesses. We are not strong in production engineering in the universities; we do not turn out enough production engineers; the status of production engineering in many companies is still too low; project management skills are lacking, they are not specifically taught in universities, they are not sufficiently extolled in industry and experienced project management teams rarely survive in industry because their value is not appreciated. As the product or process with which they have been concerned goes into its commerical phase, the project management team tends to be dispersed into sales, production and marketing, etc., and when the new innovation comes along a fresh project management team has to be assembled.

The importance of project management is well recognised within AIRTO, and one of the reasons for the increasing involvement of AIRTO members in industry and the increasing demand for their services, is that AIRTO members do possess skilled project management teams who remain in existence to serve client after client.

Q4 *How effective are the activities of Government departments in promoting and supporting innovation?*

Government departments are no longer as effective as they need to be in promoting and supporting innovation, and the attempt to catalyse industry into more direct investment on its own account has not, in AIRTO's opinion, really succeeded. The recent CBI critique of the R&D Enterprise Initiative shows how inadequate the present resources of the DTI are and also how the motivation has been reduced by the near market philosophies of the present administration. One of the main areas of the Government in promoting innovation has been in defence. This has been the major thrust, and as mentioned earlier. AIRTO members who have had defence contracts have been very effective in transforming the technology so generated into civil application.

With the running down of the Establishments, with the proposal to form the Defence Research Agency and especially with the possible lessening of the need for a high defence position due to improving East/West relationships, the ability and willingness of Government to support innovation through defence contracts is itself much less than some ten years ago, and this also is tending to erode the UK technological base.

Q5 *What are the effects of City attitudes to investment and innovation?*

City attitudes do not encourage companies to indulge in long-term innovation, especially if this reduces the short-term profit margin. The City has turned away from technology in recent years; there are now fewer specialist technology investment trusts than there were, organisations specifically set up to encourage technology on the NRDC model, such as Prutech and Cogent, have been virtually disbanded, and companies which have been committed to long-term innovation and hence reduce their profit margins have been prone to take-over.

Sometimes City attitudes also appear to be tied in with unreasonable expectations and pay-back time, and nationally we are lacking when it comes to taking the long-term view of investment in innovation and innovative needs. AIRTO would like to see investment in R&D a legally necessary item to be included in the published accounts of a company and accepted as an indicator of the technical health of an organisation.

Q6 *What is the effect of the legislative and regulatory framework concerning, for example, labour costs, patent laws and tax concessions on R&D and the purchase of know-how?*
With regard to the effect of the legislative and regulatory framework concerning, for example, labour costs, patent laws and tax concessions on R&D and the purchase of know-how, AIRTO has no comment other than that the very high initial costs (R&D) could perhaps be more positively recognised in tax concessions, bearing in mind the long-term pay-back period.

Q7 *How effective are the mechanisms for technology transfer from HEIs, Research Councils and public laboratories to manufacturing industry?*
Technology transfer depends very much on the will and ability of industry to receive the technology transfer. Effective technology transfer is market pull oriented, not technology push oriented. On the whole the large companies have excellent relationships with HEIs and are reasonably effective in picking out from these institutions the technology they require. The problem is with small and medium sized companies who are increasingly relying upon the technology transfer skills of AIRTO.

The primary task of HEIs is to train well educated people for industry both through undergraduate teaching and post-graduate research. Technology transfer is then by transfer of people and by the research contracts placed at the HEIs by industry. This latter mechanism can be very effective in technology transfer provided that the work is fundamental in nature.

Real problems exist in transferring technology from HEIs to SMEs. There is a lack of understanding by both parties. SMEs in general have very little appreciation of the nature of the work and the goals of HEIs, and similarly, university staff have little rapport with the methods employed by SMEs. AIRTO is of the opinion that RTOs have a role to play as an intermediary in transferring technology from HEIs to SMEs. RTOs employ graduate staff who are familiar with academic research on the one hand, and the methods employed by SMEs on the other, and hence are in an ideal position to bridge the gap between the HEIs and the SMEs.

Q8 *Does the UK benefit sufficiently from EC support for innovation? How might it be improved?*
Leaving aside the UK benefit from the EEC directly, it has to be said that the European programmes are always heavily over subscribed in application terms, and under funded in terms of the breadth of the programmes. AIRTO would like to see more of the Community's budget spent on industrial and environmental matters, and less on the CAP.

Q9 *What are the effects of the varying relationships between companies and their suppliers?*
Relationships between companies and their suppliers are very important in the innovation process. The most striking example in the UK, of course, is the Marks and Spencer example, where by a very close relationship Marks and Spencer does encourage innovation among their suppliers because they provide a guaranteed and understanding market. Very much closer relationships between companies and their suppliers along the Marks and Spencer model would encourage more effective innovation in UK industry. Another example is innovation in the motor industry, initiated by the Ford 101 quality document.

Q10 *What factors influence decisions to invest in innovation in the UK or overseas?*
The main factor which influences decisions to invest in innovation is the perceived market opportunity that will result from such investment. Without doubt there are examples in the past of innovation being entered into purely from technical interest, as opposed to overall economic considerations. Obviously there will be instances where market factors cannot be accurately quantified, and as such the innovation represents a high risk. There must be room for a proportion of such investments, but predominantly innovation will be guided towards market needs.

Q11 *In the light of ACOST's report "Defence R&D: A National Resource", and the Government's response, is there a satisfactory relationship between the defence and civil sectors?*
The ACOST report, and in particular the conclusions 6.13 and 6.14, and recommendation 6.15, address this question. To date there is little evidence that recommendations are being put into effect. Specifically, investment in manufacturing processes could yield substantial cost savings in the defence budget, as well as improve the overall competitiveness of manufacturing industry.

J A BENNETT
Hon Sec AIRTO
21 May *1990*

Memorandum by W S Atkins Consultants Ltd.

INNOVATION—ECONOMICALLY SIGNIFICANT APPLICATION OF NEW KNOWLEDGE OR TECHNIQUES

SUMMARY

The act of innovating has been described in order to identify the features which contribute to its success. They include knowledge and awareness of the real need.

Many people possess knowledge but the real need is often not identified.

Bringing knowledge and need together is identified as a major problem.

Motivation of individual workers is seen as a significant problem but collaborative groups involving industry, research organisations and universities is recommended as an effective way of setting up a formal structure to examine the component parts involved in innovating.

The recent DTI Advanced Robotics Initiative is cited as a good example of innovation at work.

INTRODUCTORY COMMENT

Before considering the state of innovative activity in industry it is important to understand the exercise of innovating.

The dictionary describes innovating as "introducing changes", but the changes must enhance the product, process or routine and be economically viable. So in industry it is understood that the word improvements can be used in place of changes.

Innovation requires two things:

A. A thorough knowledge of the medium within which one is working—technology, process, management routines, etc.
B. A true definition of the real need.

Innovation combines A and B to arrive at C the improvement

$$A + B = C$$

When A and B exist, obtaining C can be an unconscious process as many ideas for improvements testify. It is this unconscious nature of innovation which makes it difficult to understand and manage, thus creating the need for special attention by the select committee in the House.

Q1 *What are the effects of company attitudes and structures?*

1.1 Company attitudes—Most company activities involves the mechanical action of processing routines, often in the form of delegation. The situation needing processing is often overlooked and sometimes not identified as a problem. Many of these situations only receive attention in the lower ranks who are often remote from the problem and fail to identify the real need.

Innovation is very much an individualistic activity because it is difficult to manage, but there is scope for brain storming sessions to stimulate lateral thinking. Think tanks have been employed by governments but not so much in industry.

1.2 Company structures—Much of higher management is primarily concerned with increasing the work load—securing contracts. Indeed it is this which is rewarded and drives people into sales where human psychology—relating to customers and others in the same organisation is the most important requirement. In the past there has been attempts to encourage companies to involve technical staff in the decisions made at high levels. But innovation is not only the province of technical staff and the boardroom is perhaps not the best place to foster innovative thought.

Q2 *How active are UK companies in seeking out external technology?*

They do attempt this but item 1.1 of this reply forms a barrier—the real need is mostly not identified so they seek with incorrect questions.

This is compounded by the wealth of information which is available and the item 1.2 of this reply—the drive to produce more.

Q3 *What are the respective roles played by development, production and innovation?*

The roles have been set up to achieve technical expertise from the development team and process skills from the production staff. It is well known that they can become separate camps and attention has been paid to creating cross fertilisation between them. This has only resulted in new designs being productionised—changing the design so that it can be made with the process equipment currently available. Quality circles employed by companies with Just-in-time and Total Quality Control in place are a good example of tackling the day to day production problems.

The roles are correctly defined but there needs to be more contact during the period when the real needs are being formulated. This is not new and some companies succeed.

Q4 *How effective are the government departments in promoting and supporting innovation?*
There have been many attempts by government departments to encourage innovation. In the 1960's government contracts were placed with machine tool builders to design and build advanced machines, in order to generate skills in computer controlled machine tool technology. The recent Advance Robotics Initiative by the DTI is a good example of government support.
There is however often a reluctance in government circles to approach the stages near to realisation of the conceptual work. This is because of economic stringency but this could be examined in greater depth particularly with regard to the risk of losing effective return on the early work.

Q5 *What are the effects of city attitudes to investment in innovation?*
It is well known that investment in innovation is risky and that many ideas are developed to economically viable products outside the UK. Financiers are not in the best position to judge the value of innovative ideas but there is a difference, as the sub-committee have identified between inventions and the application of ideas which can create wealth for the country.

One of the biggest effects which the City had upon innovation is their policy of short-term investment. Japan is often praised for long-term policies and the desire for this approach in the UK has often been expressed by the CBI among others.

Q6 *What is the effect of legislative and regulatory framework?*
Legislation, as has been seen in the environmental issues, can create a demand and create a climate for new industries, e.g., oil spill technology.

Q7 *How effective are the mechanisms for technology transfer?*
Companies keep abreast of the state of technology through books, magazines, conferences and exhibitions, and being active in the technical field.

It is an individualistic endeavour and the companies are only as good as their employees. Individuals, can however become isolated particularly in small companies and to succeed the innovators must have access to the main thrust of technological development. The well known saying that "It was not developed here" can be a stumbling block to adopting new ideas.

Collaborative groups are an excellent way of bringing different groups of individuals, with different skills, together to look in a multi-disciplinary way at developing technology and its adoption to the manufacturing industry.

Q8 *Does the UK benefit sufficiently from the EC*
Most manufacturing industries do not benefit significantly from the EC. Europe is still a collection of different nations and nations as well as other companies are often seen as competitors.

Q9 *What are the effects of varying relationships between companies and suppliers?*
This has been improving with the advent of Just-in-time techniques and the introduction of quality circles. This works because problem areas are exposed to larger groups who begin to understand the real need. This must be encouraged.

Q10 *What factors influence decisions to invest in innovation?*
The first factor is—Will the proposed new ideas produce a satisfactory financial return?

The second factor is—Has the market sector where innovation is needed, been correctly identified?

Q11 *Is there a satisfactory relationship between defence and civils?*
Much of the defence work is of high quality but it is protected and because of the difficulty in ensuring protection, more information is withheld from the civilian sector than need be.

Collaborative groups could include technologists from the defence industry but with a non-protectionist brief.

R R GIBSON
April 1990

Letter from Barclays Bank plc

I refer to your letter of the 8 May 1990, addressed to Mr Andrew McThomas, Public Affairs Manager of Barclays Bank, inviting written evidence from the Bank on the role of Clearing Banks in financing innovation and, on the availability of "patient money" for long-term investment.

In your letter you listed specific questions which the Sub-Committee is considering and, where appropriate, our answers to these questions are set out below.

We should mention that the Bank's Corporate Division, which handles our relationships with large multinational and domestic companies, has already been approached to answer these questions by the "Centre for Exploitation of Science and Technology" (CEST). Their answer covered the Bank's involvement in Defence Technology Enterprise (DTE) and, in particular referred to the DTE in their answers to Questions 4 and 7.

Our answers to these specific questions are as follows:
Questions 1, 2 and 3
We are unable to comment.

Question 4
In addition to the information contained in the letter to CEST, we have had various discussions with the DTI over the past few years on their plans to encourage innovation, and from our limited knowledge of them, these initiatives would appear to have been well received by those companies who attended them.

This Bank has also recently sponsored the production of an "Innovation Toolkit" (which has been written under the auspice of the NEDO). This is a self-diagnostic Toolkit for companies so that they can identify any organisational and attitudinal constraints that there may be and encourage innovation within their own organisation. This has only just been launched and as yet we do not know how successful a product it will be and, therefore, what effect it will have.

Question 5
As we pointed out to CEST, there is often confusion caused by the use of the generic term "City" as the City is a combination of different financial institutions who will naturally take different attitudes towards finance in general and, therefore, to the finance of innovation in particular. There is obviously a difference between public equity and debt markets and the private debt market, and as our commercial banking operation operate in the latter our comments should be viewed from that perspective. We believe the Committee is quite correct in distinguishing between innovation and invention and it is our view that over the longer term, innovation as defined by the Committee, is a prerequisite for survival. Therefore, businesses will naturally approach their commercial banks for financing of their activities, and banks will view each such request against the normal canons of good lending. This will, of course, include the businesses track record, our assessment of the risk and return, the financial resources of the borrower, and our assessment of the management capabilities of the business concerned. Therefore, with innovation being important for economic success, the Bank is likely to be indirectly financing innovation, in that by providing conventional finance for working capital and investment in machinery, it is freeing-up internal resources for innovation. Banks are lenders of working capital by way of medium-term finance secured against Balance Sheet strength or against assets.

We are therefore keen to support well-managed companies and increasingly such a definition will have to include being innovative.

Question 6
Unable to comment.

Question 7
We have nothing to add to the comments given by our Corporate Division to CEST.

Questions 8, 9 and 10
Unable to comment

Question 11
Our Corporate Division covers this in their response to CEST.

As far as "Patient Money" is concerned, you will be aware that this is not available from a Clearing Bank because, as stated above, we are essentially lenders of short/medium-term funds. However, we do have two Capital Funds who are providers of equity finance, namely Barclays Baronsmead Fund and Barclays Development Capital.

This Bank has had considerable experience in financing high technology and we believe that Committee Members may be interested to read the evidence submitted by Philip Howell, Assistant Director in our Bank's Corporate Division, to the House of Commons Parliamentary Information Technology Committee in January 1988. *[not printed]*

A B VAUGHAN
Business Sector Marketing Director
24 *August* 1990

Memorandum by Dr P Bate, School of Management, University of Bath

THE CULTURAL PARALYSIS OF INNOVATION

THE CASTALIAN CULTURE

Pathways to an innovation-free World

This paper explores the way in which organisation culture impacts upon the process of innovation. Moving away from the traditionally "hard" technological and economic viewpoints on the subject it argues that innovation initiatives, even technically spectacular ones, can often fail because of problems within the culture of the organisation, and more especially its managerial culture. Such initiatives are paralysed by "circles of culture", organisational microcultures which trap new ideas and prevent their full development and exploitation. The paper explores the nature of these circles and their negative impact on the cultivation and diffusion of innovation. Its exploration of the culture-innovation relationship is both real and imaginary, involving the juxtaposition of a true story about a failed innovation (British Rail's failed Advanced Passenger Train project) with a fictional story about the "perfect" innovation-free culture (Castalia in Hermann Hesse's novel "The Glass Bead Game").

PROLOGUE. A TALE FROM THE FIELD: "THE APT FIASCO"

It may be a cliché, but British Rail's "Advanced Passenger Train" (APT) will probably go down in history as one of the most successful innovations ever to have failed. For some time to come transport industry analysts will be trying to unravel the mystery of how one of the most promising and far-sighted passenger train developments of all time turned into a huge failure, wasting nearly twenty years of research and development within British Rail (BR), and depriving Britain of the cornerstone of her intercity railway strategy for the remaining years of this century and beyond.

Had BR's plans reached fruition, APTs running at up to 250km/hour would at this moment be whisking passengers along the country's rails in what the train's protagonists liked to call the "squadron service" (Hughes 1988:50). And with completion of the Channel Tunnel in several years time, the train would have provided the ideal mode of transportation for international rail travellers, offering the perfect foil to the French high speed trains operating on the other side of the English Channel.

Now, of course, this all needs to be couched in terms of the "might have been". The APT never actually made it into active service. The project was abandoned and today only one of the original trains still survives —as a museum piece. The other prototypes went for scrap. A poignant symbol of the "casualties of war" was a picture which appeared in a national newspaper at the time. It showed one of the doomed APT's sitting forlornly in the breaker's yard, wheel-less and leaning over on its side. Burly men with sledgehammers were standing on the roof of one of the coaches smashing out the windows below their feet. Hardly a fitting end for what had once been called the "train of the future" (Nock 1983:7).

The story of the APT goes back some twenty years to 1967, when BR's Railway Technical Centre in Derby first launched its plans for a new generation of high speed trains. This was to be an "all or nothing" approach (Potter 1987:195), offering both a challenge and a charter for radical innovation. The framework of objectives the members set for themselves was far-sighted, incorporating environmental concerns that have become fashionable only relatively recently. The broad objective was to build a high-performance train to run on existing track. The list of specific objectives read as follows:

(1) Achieve a maximum speed 50 per cent higher than existing trains.
(2) Negotiate curves at up to 40 per cent faster.
(3) Run on existing track with existing signalling.
(4) Maintain standards of passenger comfort at higher speeds.
(5) Be efficient in energy consumption.
(6) Generate low community noise levels.
(7) Maintain existing levels of track maintenance.
(8) Achieve a similar cost per passenger-seat kilometre.

"These objectives determined the main innovations that the APT had to incorporate, which together represented the most radical jump in rail technology ever attempted" (Potter 1987:59).

The result, as one commentator (Hughes 1988:50) put it, was a train "oozing with technological goodies". Not content with making modifications and improvements to existing train technology, the scientists and engineers at the Centre had set in motion a programme of fundamental research, its objective being to find solutions to a number of hitherto intractable rail problems. One such example was the problem of "hunting": ever since the 1840s railway engineers had been aware of the tendency of a train's cone-shaped wheels to vibrate uncontrollably as speed increased and to become unstable ("rapid lateral oscillation") thus effectively putting a ceiling on the maximum speed that any train could comfortably attain (approximately 100mph or 160kmh). By finding solutions to various theoretical problems associated with hunting and subsequently incorporating these into a radically new type of bogie suspension system, the APT scientists were able to achieve—indeed far exceed—the design speed objective (200mph or 320km/h). They had thus solved a problem of 150 years standing, an event as significant in railway terms as breaking the sound barrier.

Other innovations followed hard on the heels of this one: lightweight, aerodynamically designed body structures (weighing 40 per cent less than conventional trains and giving a 30 per cent fuel saving at comparable speeds); low unsprung mass technology (substantially reducing track damage, and therefore maintenance costs); and new non-friction hydrokinetic brakes that used the principle of a water turbine in reverse to stop the APT from its maximum speed of 250 km/hr in the same distance as that taken by conventional loco hauled trains from their maximum speed of 160 km/hr. Most original of all, however, was the revolutionary concept of the "tilting body" mechanism for the train. This is described below.

Railway lines had been constructed in the second half of the nineteenth century when speed potential had not been a major issue, and when it had been more important to avoid offending the powerful landowners whose land they had to cross than to concentrate simply on finding the shortest possible line between two points. The resulting railway network featured a good deal of imperfect, sharply-curved track, resembling as one commentator put it, the "proverbial dog's hind leg" (Nock 1983:84). Knowing that the high economic and environmental cost of the French solution (building new "motorway-type" track) was politically unacceptable, the Centre concentrated on the cost-effective option of designing a vehicle which would run smoothly at high speed over existing track. In the end they did find a solution which, if it had been successful, would have equalled the French for a cost of only one-fifth (Hollingsworth 1985:215).

The method involved using a tilting body mechanism to counteract the powerful centrifugal forces exerted upon, passengers as they hurtled round the tight bends. The tilting mechanism was designed to operate automatically in response to the lateral accelerations experienced by the passengers. Sensing devices were installed which measured the effect of these forces, separately on each vehicle of the train, and these would activate an electro-hydraulic servo mechanism which would smoothly and rapidly make the necessary adjustments (cf Nock 1983 for details). The tilting suspension is shown below. The amount of body tilt could rise by as much as nine degrees, which meant that at full tilt one side of the car could be as much as 400mm (16in) higher than the other. The theory was that passengers would experience nothing unduly strange or out of the ordinary as the result of travelling in this "out of the horizontal" position. Because of the elimination of all centrifugal forces they would in fact enjoy an extremely comfortable ride. That at least was the theory.

The speed improvement on curves was estimated to be anything up to 50km/hr, which translated into journey times meant that an average five hour journey would be reduced to less than four hours.

Other foreign railways, notably those of Canada, Italy, and Japan, had begun to experiment with advanced concepts such as these, but none of them approaching the ambitiousness of the British scheme. Indeed, so far ahead of the field were the APT's innovations that licence deals to use them had been immediately snapped up by more than thirty foreign countries.

By any standards BR seemed to have a "winning package", and few would have predicted the debacle that followed. First came the delays: it took two years for BR Research to persuade the British Railways Board and the Ministry of Transport to support and fund the APT project. Although the project did finally receive the go-ahead there were times during this period when, despite all the signs of BR having a potential success on its hands, it came perilously close to being axed. An industrial dispute over the proposed "single driver operation" and the "blacking" of the APT caused a further fourteen-month delay to the test programme between July 1972 and September 1973.

After some promising trials in 1975, in which British speed records were broken, several technical and manufacturing problems began to appear: the tilting mechanism was jamming or failing, brakes were overheating, failed bearings in the hydrokinetic brakes were overheating, failed bearings in the hydrokinetic brakes caused an axle to explode, and gearboxes were failing due to lubrication weakness and oil leakage through seals (Potter 1987: 126-129). Some of these were just technical "snags", while others were discovered to be fundamental design faults. In 1978 a combination of these led to the dramatic derailment of an APT prototype at over 160km/hr (100mph). Miraculously there were no fatalities.

In 1981, a full three years behind schedule and under pressure to show results on BR's 43 million pound investment, the project managers decided the introduction of the train into public service could wait no longer. As later events were to confirm, this decision to "go live" ultimately proved fatal for the train. The troubles began on the first day of the public launch. A group of newspaper reporters who were travelling on the train, and who had consumed generous quantities of alcohol—courtesy of British Rail—began to complain of "seasickness" every time the train went round a bend. The problems the waiters were having serving "high speed" kippers were nothing compared to the problems the passengers were having eating them!

Predictably, the next day's newspapers carried the story of this nauseous experience in full technicolour detail. From now on the trials and tribulations of the APT were to turn into a daily household spectacular.

On another run shortly afterwards the train's tilting device failed, bringing passengers abruptly to their upright positions, and causing glass and crockery to be broken. Yet another trip was aborted because of ice-blocked air pipes and brake failure. Only one out of the first six trips actually reached its destination. All of this happened in a blaze of publicity during which time a spiteful and gloating press worked ceaselessy to turn the APT into a music hall joke. Fearing further public humiliation BR withdrew the train from service. Finally in 1985, in a classic euphemism that only bureaucracies can produce, it announced that the APT programme was to be "deferred indefinitely". In a word, scrapped. And so it was that the train was withdrawn from service. It never ran again. From drawing board to scrapheap had taken nearly two decades.

The Postmortem: Steps towards a cultural diagnosis

Why did the APT fail? Why does any "winning" innovation fail before it can be put to practical, commercial use? Clearly technical and manufacturing problems can never be underestimated, but are these alone an adequate explanation? This paper argues that they are not. Joining with others who have also examined the APT fiasco (Potter 1987; Hughes 1988) the paper proposes that the technical failures on the APT were merely symptoms of a much deeper problem of trying to manage a complex, innovative project within a large bureaucratic organisation. The stress is on the words "manage" and "organisation": the APT failed not because it was a "bad" train but because the project was badly organised and badly managed. It was not the culprit but the victim of organisational circumstances.

> "Some of the technical problems were certainly very difficult to tackle and there were some differences in engineering standards and approach between the APT project team and component manufacturers and train assemblers. But there was no reason why these should have produced a total barrier to innovation. It was in the management of the APT project that the true seeds of failure lay." (Potter 1987:131)

This paper concentrates on the organisational and managerial reasons why technologically advanced programmes like the APT go nowhere. It uses a simple conceptual framework in which the organisation and its management process are seen as mediating between an idea and its realisation, pulling and pushing it in different directions, sometimes helping it to materialise, sometimes impeding it, and sometimes halting its passage altogether.

Kanter (1988) expresses this notion metaphorically, with the organisation being the soil medium in which innovations—"the thousand flowers"—bloom and grow, and its managers being the diligent tillers of this soil! According to this concept, innovations are just like flowers of the field: they need the right conditions to take root and grow, and they need proper cultivation and wise husbandry.

Organisations vary in this regard. Some provide rich and fertile soils for the creation, promotion, and exploitation of new ideas, while others leave things to drift with the superb aimlessness of the wild. Some ensure that the seeds of innovation are never sown, and others perversely wait until they have grown and then trample them down. Different modes of organisation provide different levels of support and nourishment for the fragile and tender process of innovation. It is well known, for example, that large-scale machine bureaucracies like British Rail sit uncomfortably within this metaphorical arena—they are the blot on the landscape, probably the last place on earth one would choose for the cultivation of innovation. As Mintzberg indicated, "efficiency is their forte not innovation", (1979:346).

Innovation is therefore an organisational issue as well as a technical issue. The practical implication is that innovation needs not only technical development process but an organisation development process as well, since the "limits" to innovation are as much organisational as they are technological. Projects like the APT ultimately fail because the organisation, not the technology, has reached its "limit"—the organisation has in some way over-reached itself. Organisation development practitioners have a crucial role to play in understanding and explaining the nature of these limits and discovering ways of extending them.

But what are these limits? The most obvious ones are "structural": Potter (1987), for example, describes how progress on the APT prototypes slowed down after the decision was taken to incorporate the Project Team into the functional structure of the Mechanical and Electrical Engineering Department. In the hurly-burly of daily departmental life, the Team came under pressure to abandon its "distracting high-tech irrelevance" and get down to work on the "real" day-to-day problems of "real" trains—a classic role conflict induced by this particular structural arrangement, which was only solved later by the adoption of a matrix structure (and even then only partly). What happened in the case of the APT is consistent with Oakley's (1984) general observation that departments with a functional structure, which efficiently carry out routine tasks, tend to be "mechanistic" and unsuited to activities like innovative design, which require a more flexible "organic" structure.

This connection between organisation structure and the innovation process suggests that organisation designers have an important role to play in providing the right soil structure for innovations to take root and grow. This issue will not be discussed further in this paper. However, the point should be made that changing structures, though important, may not be enough. Even the most "innovation-friendly" structures, like the matrix organisation, will fail if cultural problems like the ones described in this paper have not been addressed.

The second type of limits are "political" and "attitudinal": the powerful "trustees" of the status quo (Stevenson & Gumpert 1985), perceiving an innovation initiative to be a threat to their values or position, devise strategies and tactics for obstructing its progress. There is always an old guard in organisations willing to resist any form of change, regardless of its merits. In this BR was apparently no exception:

> "Railways are a conservative business, and the innovative APT . . . was anathema to the traditionalist school in BR management. They believed it a waste of time, money and effort, resenting it as an intrusion in their domain. They fought it behind the scenes, undoubtedly contributing to its final downfall." (Hughes 1988:50)

"Structure" and "attitudes" are the two most frequently cited reasons for the collapse of the APT project. A third one is proposed in this paper: the "cultural" reasons. Drawing on data from a study carried out by the author in British Rail at the time of the eclipse of the APT project, it argues that the more radical change endeavours, like the APT, were "paralysed" by BR's organisation culture—to be more specific, by its senior management culture. Structural and attitudinal problems were certainly encountered during the study, but many of these were found to be symptoms of the cultural problems affecting the senior management process at the time. The management culture was putting a straightjacket on innovation, restricting its growth and development. In Kanter's terms it was offering an extremely thin topsoil for the nourishment and growth of the APT project, laying down a whole set of inflexible norms governing what was acceptable and unacceptable, thinkable and unthinkable, possible and impossible in the organisational situation.

The argument presented here is that the "limits" to any technological innovation, are not so much physical, technical or structural, as cognitive and epistemological, being built-in to the basic conceptual mechanisms and the knowledge structures that people, individually and collectively, use to make sense of and respond to the novel situations that they experience in their working lives. These social schema (Harris 1990:5) may be found within any organisational community—in a senior management grouping, for example. They comprise the presuppositions or a prioris of any process of interpretation, providing a relatively fixed frame in which new experiences are situated and embedded. It is upon such "grids of meaning" that developments like the APT come to acquire a particular significance for the people involved. It might therefore be said that schema set the frame of thinking for innovation, giving "cognitive status" to the social and physical world in which it occurs; they define, for example, what a new railway train "means" to and for the people involved, and what action they take in the light of this. As the sociologist and philosopher Georg Simmel explained in his Theory of Forms:

> "Aspects of reality can be grasped as possible objects of experience and knowledge only if they fall under some constitutive form. It follows that a form may be represented as a taxonomy, a system of classification, or a conceptual scheme that performs an epistemological function: it defines the conditions under which the world can be experienced and represented in a certain way . . . A form, therefore, identifies the conditions under which a certain kind of cognitive status can be ascribed to a given item."
>
> (Simmel quoted in Oakes 1980:10)

These interpretive forms of schemes are the basis of organisational thought and action, determining the way members of a collective organise their experience and construct their behaviour. All knowledge and experience are mapped onto such schematic forms. They are obviously fundamental to the way people think about the whole business of innovation and change. As the novelist Julian Barnes put it:

> "Form isn't an overcoat flung over the flesh of thought . . . it's the flesh of thought itself. You can no more imagine an Idea without a Form than a Form without an Idea."
>
> ("Flaubert's Parrot" 1985:36)

Forms are therefore cognitive imperatives: they require that the world be seen in a particular way. Simmel has aptly described them as "discriminations" superimposed on life. They are the fine filters through which any new development must pass on its route towards acceptance and implementation—even a high speed railway train!

Organisational reality for everyone, including the management community, is constituted by a multiplicity of such forms, each having its own characteristic language and logic, and each producing a representation of the world that is unique to that form itself. Schematic forms clearly occupy a key position in relation to people's overall definition of the situation, and the task for researchers should be to discover how they are structured and how they function in organisational settings.

The point to be argued is that, though manifested at the individual level, they are essentially cultural phenomena; that is to say schematic forms are:

(a) **Historical in origin:** they are received orthodoxies, historical facts of life that confront the individual as an external and coercive fact (Berger & Luckmann 1966:76). They have a firmness, mundaneness (Pollner 1987) and an "of courseness" to them which often makes it difficult for people to stand back and regard them in a critical and questioning way.

(b) **Supraindividual:** they are objectified domains of thought that have become detached from the individual, perceived by him as lying mainly beyond the reach of his own initiative and control: "From the perspective of the individual . . . the world of objective culture begins to assume the appearance of a colossal domain of uncanny, threatening, and oppressive objects which he can neither appropriate nor dismiss" (Oakes 1980:37). Although the individual can make certain choices about how he is going to relate to them and interpret them, they are not things that he can personally do a lot about. They are the cultural "givens" in a situation that must be passively acquired and assimilated, the parameters and semantic rules that the individual must learn if he is to gain admittance to the various social "games" being played within the community concerned, and to share in the various pay-offs that they produce.

(c) **Communally-owned and maintained:** their function is the facilitation of commonsense-making across a set of individuals (Harris 1990:4). Cultural schema are shared and fixed by consensus. They are collective systems or programmes embedded in the tacit knowledge of the language-system as a whole (Sturrock 1986:12), part of the community's thinking-as-usual, and experienced (quite literally) as common sense.

These community paradigms (Sheldon 1980; Pfeffer 1981) fulfil numerous functions: they offer "simple facts" about the reality (anything inside the paradigm is sense, anything outside it is nonsense); they confirm the collective identity of the community and provide the basis of its moral conscience; they are a normative frame of reference for the community's members; they provide a set of "truths" within which attitudes are formed and behaviour directed; and they embody the idealised ways of thinking and acting within the community. No wonder they are cherished and protected within that community. Certainly there is a strong moral dimension to them that deters people from challenging them. This means that generally they are not interfered with by the normal, everyday process of change. And in any case, a good deal of this change is adaptive (a first order stabilising kind of change), aimed at securing synchrony or fit between ongoing life events and the matrix of forms across which they have to traverse.

In the context of the innovation process, cultural schema are too important a part of the background to ignore. The psychological, physical, and structural aspects are important too, but on their own they are not enough. An understanding of innovation and change also requires an investigation of the different cultural forms or schema within which, managerial modes of thought and action in the area of innovation are embedded.

We must therefore examine the relationship between culture and innovation, and ask what kind of cultural schema could possibly produce a failure on the scale of the APT. The purpose of interpreting the APT fiasco culturally is to show how certain fixed "habits of thought" within the management structure—ruling truths, schema, dogmas, dominant mentalities, or orthodoxies—militated against innovation, imposing limits or narrow tolerances on its development, and causing it to lose momentum over time—indeed ultimately stopping it altogether.

The study on which this paper is based was commissioned by BR's central personnel directorate, and was known as the "Culture Study". Its broad purpose was to help the management develop new perspectives on its modes and strategies of operation, and in particular on how it went about managing change. Data were gathered from open-ended interviews with 80 of the organisation's most senior managers over a six-month period, including the CEO and the Managing Directors. Although the APT was not specifically on the agenda for discussion, many of those interviewed had been directly or indirectly involved with the APT project and often referred to it.

A variety of meetings and internal conferences were also attended during this period. Apart from being a listener and observer one was also playing the broader role of the "loiterer" in the organisation's streets —such a one who, according to Homer, "stands about and rubs his shoulders against many doorposts", watching the people go about their business and wherever possible engaging them in idle conversation. Further details of the methodology, the issues uncovered, and the two-and-a-half year organisation development programme that followed the Culture Study can be found elsewere (Bate 1990).

The emphasis in this paper is on building up a picture of the cultural reality in which the APT saga unfolded, and then using this picture to pinpoint how and where cultural processes and innovation processes intersect. The word "picture" is very significant: with a phenomenon as immaterial as culture, the primary concern should be to use some kind of marker to outline the shape of the culture, making it "visible" to the eye, and showing how it relates holistically to other objects in the picture. Metaphor and allegory can play an important part here, and it is with this figurative approach that we begin our analysis.

ORGANISATIONAL FOCUS: THE CASTALIAN CULTURE

It is proposed that the cultures of top management groups lie at the root of the problem of innovation within large-scale organisations. The management cultures of such organisations are often rendered incapable of responding to the forces for change by the "paralysing mental structures" that exist within them —closed structures of thinking which stifle the progress and development of the innovative process. A close examination of the activities of senior management groups shows that they are frequently empty of any strong innovative orientation or capability. The striking feature about them is their dynamic conservatism (Schon, 1973); they have a circularity to them which reproduces infinite refinements and permutations of the old, whilst producing very little that is new. They can manage incremental, "first order" change within the existing frame or paradigm (Watzlawick et al 1974)—a form of change that is well-suited to imitative, evolutionary, or "improvement" kind of innovation—but are incapable of responding effectively to the discontinuous "second order" paradigm changes that the more radical, research-based initiatives like the APT demand.

Dynamic these groups may be, innovative they are not. Their thinking and action have become culture-bound. Their cultures are autopoetic or morphostatic systems: they can **re-form** or re-configure the "reality" but not **transform** it (Smith, 1984). Hence, the denizens of these cultures, in the manner of the Castalians in Hermann Hesse's classic novel "The Glass Bead Game", are to be found earnestly engaged in a process dedicated to the refinement of the inner elements of a sophisticated, but nevertheless static, cultural form; improvising but never innovating; trapped inside a self-contained bubble:

"The Law, in one great formulary bound,
Forming a whole, a still unbroken round."
(Hesse 1972: 412)

Or like the figures in Escher's painting "Relitivitat" they spend a lot of their time just walking round and round the same "circle" of three-dimensional staircases, perpetually moving from one point to another but always within the same fixed space, the staircases representing the scaffold upon which the past is retraced and the "known" endlessly rediscovered: the pathways of an innovation-free world.

Both "pictures" are a cogent symbolic illustration of the kind of organisation culture to be described in this paper. Obviously they are not included for their literal truth but for their metaphorical significance. In this "first impression" (itself a publisher's metaphor for a particular version or edition of a story) these two images—Hesse's in particular—are used as a Gedanken experiment for the phenomena to be described, selecting certain aspects of reality for representation and exaggerating them in the interests of a particular interpretation (Oakes 1980). As metaphorical "texts", they are especially well-suited to the subject of culture. The "Province" of Castalia in Hesse's novel translates smoothly into the Schutzian concept of a "finite province of meaning"—a culture, one might say. Furthermore, Castalia is a compelling symbol of the "strong culture" that various writers—especially the business "gurus"—have been earnestly urging organisations to adopt. Clearly Hesse's work is a more sober reflection on the "strong cultures" ideal, raising serious doubts about the wisdom of blindly pursuing it, and challenging the conventional wisdom that has grown up around it. The whole point about strong cultures, which is brought out in Hesse's book but not so far in the organisational literature, is that while they may be an ideal soil medium for minor "improvements", modifications of existing and processes, technical services and other work with a short time horizon (evolutionary or "cut and try" innovation) (Freeman 1982), they are a desert as far as radical research-based innovations are concerned.

For those who are not familiar with the book, Hesse's novel is written in the form of a biography of a master of the Glass Bead Game, Joseph Knecht, compiled by an anonymous scholar. The story centres on Castalia, a tranquil and isolated province located in the mountainous region of a larger state. Castalia emerged out of the countermovement to an age of growing cultural fragmentation within the larger state. This previous age, the "Age of Feuilleton" as it was known, "was distinguished by a profusion and proliferation of the artifacts of culture. The result was confusion and chaos, a culture of disorder that had lost its bearings" (Oakes 1980:42-43). Significantly for this text, however, it was also a "culture of innovation", being open, pluralistic, free-thinking, rebellious, sceptical towards authority, energetic, curious, romantic, undisciplined, unorthodox and "given to untrammelled individualism" (Hesse 1972:21). A truly Post-Modern Age if ever there was one!

Castalia is the antidote to this post-modernistic chaos, the model of unity, order, persistence and harmony, a world from which all major innovations have been excluded. It is a retreat from the world of constant change, serving as a haven for all those who need to believe in the One Reality. The Glass Bead Game, around which the life of the Province is organised, is the means whereby the constant steady state of the Order is maintained, and the entire intellectual content of the universe grasped:

"We draw upon the iconography
Whose mystery is able to contain
The boundlessness, the storm of all existence,
Gives chaos form, and hold our lives in rein."
("The Glass Bead Game", poem in Hesse 1972:415)

A "first order", crossword-puzzle solving mentality is ideal equipment for the game, a rule-following mind that derives stimulation from producing endless variations on the stated theme. The point of this vocation, if it has one, is reformulation not innovation:

> "The most salient aspect of this new mentality was that serious men no longer produced new artifacts of objective culture." (Oakes 1980:43)

The game is symbolic, its outcomes immaterial. It is an inconsequential mind-game, "an exercise in memory and improvisation" (Hesse 1972:33), a game of recall, a backward-looking game requiring nothing in the way of vision. Its rules are fixed. Variations and alterations are subject to the strictest control. It is also not a game for "individuals". In order to play the game one has to be prepared to let one's individuality be absorbed in the hierarchic function of the game: "we find all the more worthy of our reverence the memory of those who tragically sacrificed themselves for the greater whole" (Hesse 1972:17). Castalian culture is the perfect synthesis of the individual will with the collective will, the ultimate in "groupthink" and personal disempowerment.

The game belongs to a particular genre of cultural schema whose striking feature is its closed and immanent form. Hesse calls it a "Royal Game" (120), which directly calls to mind Simmel's notion of the "kingdom" or "empire" of thought, a form of life that has established its own imperious, self-sufficient and autonomous existence. The self-absorbed monastic "ganzheiten" or high cultures depicted by Hesse and Escher are the epitome of this type of cultural form. They stand aloof and superior on top of their mountain perches. They have a strong inward focus, shying away from interaction with an outside world that they regard as brutish, coarse, hedonistic, and unpredictable. In their purest, most extreme form they represent the kind of organisation cultures to be described: closed, isolated, elitist, inward looking and unresponsive to the outside world. Dogmatism reigns supreme, deriving its strength from an absolute and authoritative belief in itself: "Our way is the right way, other ways are false, wicked, godless" (Feyerabend 1987:84). Pity the godless—or should we say the "gameless"—try to inform them of the error of their ways, but failing that leave them well alone. In the immortal phrase, these are the cultures that "stick" tenaciously to the "knitting"!

A palimpsest of the Castalian Culture described by Hesse can be found in the industrial landscape. There are Castalian organisations, and types of management culture in particular, which have similar features: order and tranquillity, isolation and ethnocentrism, historical continuity, strict adherence to routine, discipline, control, self-restraint, pride, stability, hierarchy, structure, a sense of tradition, impersonality, unity and a sense of collectivity, loyalty and dedication, uniformity, asceticism, ritualism, ceremony, rationality, and possibly above all else a high level of intellectual refinement and rationality: Castalia, as described by Hesse, is "a community of the mind" (274)—the pedagogical province ruled by Logic and Reason.

And where precisely are these communities to be found? Argyris (1970) claims that wherever there is a pyramidal structure the potential for their existence will be present, the implication being that Castalia may be found almost anywhere one chooses to look. The last feature is usually what gives the Castalian culture away. Argyris calls it "cognitive rationality":

> "Feelings and emotions are to be played down. This value influences executives to see cognitive, intellectual discussions as relevant, good, workable, and so on. Emotional and interpersonal discussions tend to be viewed as irrelevant, immature, and not workable." (1970:64)

Given this description it is not hard to see why Castalian cultures are often encountered in the large-scale, Weberian-type machine bureaucracies like British Rail: "Such organisations look inward rather than outward. Customers, or suppliers, or competitors, or even what is going on in the outside world, seem of far less importance than the endless struggle to achieve and operate the perfect bureaucracy" (Harvey-Jones 1989:73).

Castalian cultures are, however, more ubiquitous than this, also appearing (though probably less frequently) at the other end of the spectrum in simple structures and even so-called entrepreneurial forms of organisation. One would therefore be mistaken in linking the Castalian culture with any one kind of structural configuration. The reason is that the culture concerned, like any culture, is not a structural attribute at all but the product of a certain kind of historical process—the process that formed the Castalian culture being one that any organisation, small or large, simple or complex, might equally well have gone through.

The key historical feature of the Castalian organisation is previous "success"—and success as we know may strike anywhere! It is a paradox that the organisations currently experiencing low rates of innovation —the stagnating "Castalian" cultures—are often the very same ones that were once famous for their high rates of innovation. How are the mightly fallen!

The life-cycle of Castalian organisations is classically one of "high" to "low", of rise followed by gradual decline. One thing they all have in common is a proud and glorious past. They are the "excellence cultures" (Peters & Waterman 1982) of yesteryear, companies like Singer, BSA and Triumph which in their day were household names and strongly associated with quality products. Such companies can point to a Golden Age in their history when quite exceptional heights were achieved, especially in the field of innovation, two of the more obvious British examples being British Rail's "Golden Age of Steam" and the British Broadcasting Corporation's "Golden Age of Broadcasting".

It is no coincidence that failure tends to follow success because the two are in fact related, the one being symptomatic of the other. The point about Castalian organisations is that they become the prisoners of their early success. The strong culture (Deal & Kennedy 1982) that enabled them to reach their zenith has metamorphosed into a Model of Order, the be-all and end-all of existence. The Castalian culture is a form that has allowed itself to become trapped in time, detached from "the febrile rhythm of life itself, its waxing and waning, its constant renewal, its continual divisions and ramifications" (Simmel quoted in Lawrence 1976:223). Flushed with success, trapped within their gilded cage, and believing in their own immortality, the denizens of such a culture have lost the essential will to change.

The creative life of such an organisation has thus begun to depart from it. Its culture has atrophied. It might well be on its way to joining "the famous names of the past who clung to what they knew best without being prepared to adapt and change, and slowly but inexorably saw their business disappearing beneath them" (Harvey-Jones 1989:30)

What happens to innovation in this kind of organisational culture? Basically, if it is permitted at all, it has to be consonant with the conventions and protocols of the established culture, and consequently the whole sloppy and chaotic business of innovation (Quinn 1985) is cleaned up. Revolutionary design principles are abandoned for evolutionary ones; "offensive" strategies for achieving major technological development take second place to "defensive" strategies aimed at improving existing equipment and technology. Harvey-Jones (1989:23) calls this the "adjusting and tarting up" stage, where the proverbial box and its packaging are changed continually, but the actual contents are kept the same. The once virtuous circle that produced high rates of innovation has turned into a vicious circle, a "low risk" culture dedicated to the recycling of old ideas. Because research-intensive innovation, like the APT, is considered "high risk" it becomes an early casualty of such a culture.

Unbeknownst to those involved, the decline of innovation may well have begun. It has been brought about by the same mistaken assumption that the Castalians made. Harvey-Jones explains with reference to examples from the modern setting:

> "Unless a company is progressing the whole time, it is, in fact, moving backwards. It is quite impossible to maintain the *status quo,* or a steady-state position in the international marketplace. One has only to think of the British motorcycle industry and its once-prime position to see the folly of believing you can sustain a world leading position without innovation. While such world-famous names as BSA and Triumph were moderately adjusting and "tarting up" models which in their day had been in front, the Japanese and particularly Honda looked at the situation through new eyes. They did not accept the limitations and constraints the British world position had led us to assume. They reasoned, correctly, that a substantial increase in the revolutions per minute of the engine would increase the power to weight ratio and permit a whole range of new developments. This they did and we know what happened." (1989:23)

A special "Innovation" edition of **Business Week** claimed that a similar thing had also occurred in America. America had been the birthplace of some of our greatest and best-loved innovations: the fridge, the washing machine, tubeless tyres, automatic transmission, the pop-up toaster! "But then", says the journal, "something changed. The engineer's in America's labs and factories started playing second fiddle to sales. "New, Improved" became a cliché, a buzzword of the slicksters in marketing. It took a while for US managers to realise what they had sacrificed. They chuckled when the Japanese arrived with little transistor radios. They blanched at TVs that produced vivid colours with a single cathode-ray gun. They gasped at VCRs that almost anyone could afford. America let some big ones get away" (1989:12-13).

The lesson for innovators seems clear: first-order Castalian mentalities are not enough to stave off the onset of malaise and decline. The Castalian is mistaken if he believes that he has found the ultimate solution, the "perfect" innovation to end all innovations. Any form of life, no matter how bursting with creativity in the first instance, will ossify, stabilise and rigidify, given time. Human activities need to be directed towards renewing and replenishing the stock of innovation, and this requires periodic re-orientation, "discontinuous" developments or "second-order" shifts that "punctuate the equilibrium" (Tushman & Romanelli 1985) and allow the organisation to go off in new directions. Cultural schema are a major barrier against this occurring. Managing innovation must therefore involve attempts at managing culture. The challenge is to find ways of **transcending the cultural protocols of the organisation, and liberating the innovation process from the regnant ideologies which imprison it.**

This in no way diminishes the importance of "incremental", process-oriented innovation (what the Japanese call "the result of tiny improvements in a thousand places"). It is simply saying that on its own it is not enough. Castalia is the symbol of what will befall an organisation if it goes on making constant cyclical refinements year after year without changing the basic product. The Swiss watch industry is a well-known case in point. It reached the heights of perfection in mechanical and automatic watches but were very nearly wiped out as a result of ignoring new developments in the field of electronic time-keeping.

This pattern of rise and decline is well known, being immortalised in such sayings as "pride goes before a fall", and "bust follows boom". An article in Business Week in 1984 entitled "Who's excellent now" showed that at least 14 of the 43 most innovative, best-run companies in America identified by Peters and Waterman in 1981 had suffered serious decline in the three-year period since their study had been completed (in modern, especially high-technology, businesses the cycle of rise and decline appears to be getting shorter). The profile of these companies fits that of the "strong" Castalian culture perfectly. Business Week's explanation for the failure was that the companies in question had broken some of their original "commandments" of excellence. But this paper suggests that the opposite may have been true—that they probably stuck too exclusively to their "winning formulae", naively believing that their success could continue indefinitely. Unable to recognise the real reasons for this success, they mistakenly equated them with the products of that success, and so clung to these past creations oblivious to the conditions that produced them. They pursued strategies of order when they should have been pursuing strategies of change.

It is interesting to note that this thesis about "success" sowing the seeds of its own destruction matches the one that Jan Carlzon, the president of Scandinavian airlines, put forward to account for the decline in his own company's fortunes in 1984. "When you reach your goal", he wrote, "you may become a prisoner of success" (1987:121). He claimed that SAS's "reversal" had occurred because in the first place people including himself had made the "**unforgivable mistake of assuming**": that is sitting back and taking their "winning" situation for granted. Management had been content to rest on their laurels. The decline then went a stage further: "a kind of reversal set in"; management "started retreating", pursuing "defensive strategies". The result was an organisation that had lost its direction and forward momentum. Energy and motivation began to drain away, "the atmosphere of togetherness" was eroding, "interests began to compete against one another", people were "scattering in all directions" making different demands of the company. In short, The Order was now breaking down. The culture was decaying and disintegrating in exactly the same way that it had ultimately done in the Province of Castalia.

The experience of companies like SAS strongly confirms Simmel's prediction that,

> "Sooner or later the forces of life erode every cultural form which they have produced." (Lawrence 1976:224)

And also, taking us back to the "soil metaphor", he writes,

> ". . . cultural forms are like exhausted soil, which has yielded all it can but which is still covered with the products of its earlier fertility" (1921:225).

Both quotations give a clear warning to companies against taking the Castalian option of trying to live for ever off a "tiring" soil. If they do, Simmel says, their fate will be ultimately tragic. They will become the crumbling "Tower of Babel" (1917:62) on the industrial landscape, a monument to the mortality of all forms of life. Hesse would agree. Any attempt to maintain the existing collection of cultural forms as a timeless and permanent canon (Oakes 1980:46) will result in failure. Time is no respector of great civilisations. It will see to it that they gradually become emptied of their significance, meaning and value:

The Last Glass Bead Game Player

The coloured beads, his playthings, in his hand,
He sits head bent; around him lies a land
Laid waste by war and ravaged by disease.
Growing on rubble, ivy hums with bees;
A weary peace with muted psalmody
Sounds in a world of aged tranquillity . . .
All, all are gone, and the temples, libraries,
And schools of Castalia are no more. At rest
Amid the ruins, the glass beads in his hand,
Those hieroglyphs once so significant
That now are only coloured bits of glass,
He lets them roll until their force is spent
And silently they vanish in the sand."

THE MANAGEMENT FOCUS: CIRCLES OF CULTURE

And yet we know that the outcome in the case of organisational civilisations is not always tragic. Revivals do occur, leading to renewal and replenishment of the organisation, and a new lease of life in the area of innovation. The competition is countered, the Empire strikes back, and the company in question lives to fight another day. SAS is a case in point. After its 1984 troubles it recovered and, according to Carlzon, is now enjoying a "Second Wave" of success (a Second Coming perhaps?).

So what is the key factor determining whether there is recovery or not? Carlzon and Hesse are unanimous on this point! They say that everything hinges on the senior management group, and whether or not it is able to discern the problem in sufficient time to be able to do something about it. This may account for the very different fates of Castalia and SAS. Castalia collapsed because the "Magisters" (the senior management team!) failed to anticipate and deal with the fundamental problem of maladaption. And not for the first time in history, they chose to disregard the warnings of their own internal consultant (Knecht himself)—a further confirmation of the adage that a prophet in his own land is a prophet without honour. In contrast to this, SAS's management did see the problem, did listen to advice, and were able to jointly resolve what kind of major cultural shift was needed.

The question is why the wise and august "elders" of Castalian organisations, unlike companies such as SAS, fail to see the need for change even when it is staring them in the face. For the answer we need to recall the earlier discussion about cultural schema. The explanation it offers is that senior managers within this type of organisation frequently suffer from "schematic myopia" (Harris 1990:25), a cognitive and perceptual affliction that prevents them from gaining a clear appreciation of the serious nature of the situation and the fundamental kind of action that needs to be taken. Harvey-Jones reports that he came across this myopia during his chairmanship at ICI, his label for it being "collective blindness" (1989:78). Apparently its impact could be serious, leading to a "collective lack of action" within the management community on some major issues relating to innovatoin and change.

Another way of expressing this idea of cultural blind-spots—this time relating it more directly to innovation—is to say that Castalian managers get caught up in "vicious circles" of thinking (Crozier, 1964; Masuch, 1985), or "games without end" (Watzlawick et al 1974), disengaged from the kind of frame-breaking, random experimentation, boundary spanning, and "find-and-seek' activities (Jansons, 1962) that are so essential to the discovery and adoption of the "novel symbolic modes" (Langer, 1976) for innovation and change. Though frequently played with gusto and dynamism such activities add up to little more than vigorous intracultural variation within a closed and restricted frame.

> "This meaningful and meaningless cycle . . .
> this endless, oscillating game." (Hesse 1972:272)

Because these circular processes are cultural phenomena, we shall refer to them as "circles of culture": circles in the sense of belonging to a social circle or community of people, for example a senior management group, with its own lingua franca and distinctive symbolic modes of communication; and circles in the sense of being immanent, enclosed, and self-referential wholes consisting of repetitive and circular cognitive processes. The idea is that a combination of these circles functioning simultaneously in an organisation can bring about a situation where ridiculously narrow conceptual limits are imposed upon the innovative process —in effect "paralysing" it, and halting its forward progress.

The intention in choosing a strong word like "paralysis" is firstly to convey the idea of a "disease of culture" leading to general malaise and the loss or impairment of the relevant intellectual, physical, and sensory functions for innovation; and secondly to suggest that individuals confronted by this disease are often unable to do very much on their own to alleviate their condition, irrespective of the strength of their desire or will to do so. There is a personal helplessness and disempowerment that accompanies all forms of disablement, and this particular cultural strain is no exception.

The stress on personal helplessness is a particular feature of the cultural perspective on innovation and change, this again being symbolised by Hesse's story. Joseph Knecht, the man who first became aware of the problem and spoke out about it, was Number One in Castalia, the Magister Ludi—the CEO if you will —but even he was unable to alter the tragic course of events that unfolded. Probably like many others who have tried unsuccessfully to change culture, Knecht was finally forced to give up and leave the "company" altogether. The story highlights an important facet of the cultural theory of innovation: individual initiatives for change are frequently checked by the weight of the collectively, producing what Saussure (1966:73), in the related context of the language culture, calls the "collective inertia toward innovation."

How do individuals in Castalian cultures experience their own disability and helplessness? To take some examples from the BR study, one senior manager said it was like having an "anchor" tied to his leg:

> "There are powerful, enormous mental anchors on the things you want to change. They are stuck in some pretty solid ground. Given BR's unbroken history of 150 years, it is not really surprising the chain is very long. It means you have got to work long and hard on your idea, but the trouble with that is that in the end it is easier to say "blow it"!

Another talked of "antibodies":

> "BR is an organism with some very highly developed antibodies, so that if anything endeavours to permeate it the antibodies rush in, and they're incredibly strong, and they neuter whatever is happening."

A third said that he felt like the men who "spun plates" on the end of bamboo canes:

> "You have to get all these plates spinning to make something happen, and just when you think you have made it, a plate falls off and brings the rest of them crashing down. The chances of one person getting them in the air and keeping them in the air long enough for real change to occur are very small."

This last comment is particularly reminiscent of Simmel's description of individual estrangement from the culture, which employs the metaphor of the maze:

> ". . . the relationship between (an individual's) conduct and its purposes is mediated by an increasing number of instruments, tools, and techniques . . . In simple cultures, the relationship between desire, means, and satisfaction is direct, uncomplex, and transparent. In advanced cultures, however, this relationship is no longer so straightforward and unproblematical. The middle link in this sequence proliferates and is reproduced. The use of one technique becomes dependent upon the use of another, which requires still another technique. **The result is the instrumentalisation of culture: the creation of an incomprehensible maze of techniques, mastery of which requires an apparently infinite chain-like sequence of actions.**" (Simmel quoted in Oakes 1980:37)

What all of these people may be describing is what it feels like to be a victim of a circle or circles of culture.

The "circle of culture" idea belongs to a large family of related concepts, and could easily be mistaken for any one of them: doctrines, dogmas, creeds, conventions, mind sets, orientations, value sets, semantic systems, ideologies, outlooks, prejudices, states of mind. Perhaps its nearest relatives are Harris's (1990) "social schema" (already mentioned), Scott's (1985) "managerial orthodoxies", Chomsky's (1980) "cognitive domains", Peckham's (1985) "cultural protocols" and Bruner's (1983) "formats". The last of these is probably the closest of all, even though it comes from the rather unlikely area of child psychology. Bruner defines "formats" as the microcultures that spring up between parent and child as a result of the same things being said and done over and over again with only a few variations. They have a game-like quality along with a rule-structure that develops within them:

> "A format provides a familiar locus and a familiar routine in which communicative intentions can be conventionalised and interpreted. As it becomes increasingly familiar and conventionalised it comes to serve as a matrix for organising presuppositions about what is given and what is new. Above all, a format is what frames communication and locates it in a particular segment of reality."
> (Bruner, 1983:40-1)

These "formats"—circles of culture here—can also be found in organisations. They arise in basically the same way, that is in the repetitive and routine communicative interactions between people who come into contact with each other during the course of their work. As Bruner says, formats are essentially linguistic phenomena.

Reality is constructed in the process of using a particular language. The "reality" of innovations like the APT is therefore formed not only physically in metal but also symbolically in words. Mental structures and language structures are correlative and mutually implicating. How people come to "think" about the APT (and hence what they "do" in relation to it) will depend upon how they "talk" about it—and vice versa. Putting it more formally, the meaning and significance of a process of innovation will be created daily by the linguistic enactments of those involved in the course of their everyday communications between each other (Evered 1983:126). The language theme is again strongly evident in Hesse's book, indeed the Glass Bead Game itself is described as a "language" with its own ingenious grammatical rules. Clearly the glass beads are a symbol for words and sentences, while the game itself is the symbol of how words and sentences are used to construct different kinds of reality.

Previous writers have often drawn attention to the circular nature of certain organisational processes, but rarely has this been attributed to a cultural source. The circles have been treated as **behavioural phenomena** (for example Weick's (1979) "interlocked cycles of behaviour" and Masuch's (1985) "action loops"), **institutional phenomena** (Weber's (1947) "iron cage of rules" and Meyer and Rowan's (1977) "rationalised institutional structures"), and **psychological/cognitive phenomena** (the psychoanalytic concept of the "psychic prison", Wittgenstein's (1971) "bubbles of thought", and Lukacs' (1968) "net of reified rationality")—but never cultural phenomena.

Given these alternative emphases it is not surprising that little progress has been made towards a cultural perspective on innovation and change. This is in direct contrast to what one finds in the field of the arts where, for example, innovations in music, literature, and art itself are invariably explained in terms of man's struggle against form and the search for cultural transcendence (Lodge 1981; Peckham 1985). Certainly this paper suggests that there may be much in common between the world of the arts and the world of organisations with regard to the basics of the process of invention and innovation.

(To be continued)

Author's note: At this point the monograph from which this paper has been extracted moves on to give some concrete examples of the cultural circles found during the British Rail study. This is followed by a consideration of the impact they may have had upon the fated APT project. Space does not permit inclusion of this last part here, but a full copy of the monograph can be obtained from the author on request.

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Memorandum by Professor J Bessant, Brighton Business School, Brighton Polytechnic

INTRODUCTION

The following comments relate to the question of obstacles to innovation and the conditions which stimulate it in UK manufacturing industry. Since my research experience has almost entirely focussed upon the issue of *process* innovation—the adoption and implementation of new technologies and techniques within manufacturing—I shall confine my comments to this area.

These comments are based upon a variety of research work focussed on the main problem of the organisational and managerial problems in the effective adoption and implementation of new technologies and techniques. Particular projects of relevance include:

- A comparative (two year) study of manufacturing innovation management in the UK and the Federal Republic of Germany.
- A comparative (two year) study of government and industry relations in the foundry industries in the UK and FRG (with special emphasis on innovation support and promotion).
- A continuing (eight year) programme monitoring the diffusion and implementation of computer-integrated manufacturing (and its component technologies such as flexible manufacturing systems, computer-aided design and manufacturing and computer aided production management). Much of this programme has been comparing UK experience with that of other countries, including European Community states, Scandinavia, the USA and Japan.
- A continuing programme of research on the managerial and organisational development required to support and facilitate the effective use of advanced manufacturing technology.

BACKGROUND TO THE PROBLEM

It is clear that the UK record on manufacturing performance has been poor over a sustained period and it is arguable that much of this is due to a failure to innovate in both products and processes. Criticism has focussed on three issues related to investment in technology—in particular, that there has been "*too little, too late and the wrong kind*". These historical issues are now becoming of more importance as the environment for manufacturing changes and begins to demand radically different responses amongst manufacturers.

One of the themes which has interested researchers in the area of technological innovation is the concept of "long waves" in economic life and their relationship to technological change. This began as a recognition that certain clusters of technology—for example, the emergence of steam power, the railways, electricity and the automobile—had an impact across the whole economy and fuelled a period of significant economic expansion. Further analysis, particularly by Freeman and Perez,[1] developed the idea of a "techno-economic paradigm", that is a dominant pattern which influences thinking across a very broad front. This paradigm—essentially the prevailing "world view"—defines the "common sense" rules which govern the workings—structural and technical—of industrial society and set the pattern of best practice. These persist for extended periods of time but eventually become increasingly inappropriate, and eventually the paradigm shifts, a new one emerges—and the cycle repeats itself.

The value of such an approach is that it gives us a model to understand some of the changes in industrial economic life, and particularly the role of technological change in the process. Using it we can interpret many of the features of late 20th century industrial society in terms of such a shift in paradigms. For example, there is growing agreement that the mass production models of production and consumption which dominated the first half of this century are giving way to more fragmented patterns of demand and more flexible modes of production. Such models are incompatible with older forms of organisation, especially those stressing division of labour and rigid bureaucratic organisational forms. Instead we are seeing the emergence of alternative, more flexible arrangements based on networking and decentralisation.

One indicator of this is the changing pattern of productivity growth which has declined significantly in Europe and North America but which has been maintained at a high level in other economies, notably Japan. There is widespread discussion of a "crisis" in capitalism, triggered by a variety of forces—the energy crisis of the 1970s, shortages of materials, social unrest, etc.—which is characterised by a growing lack of stability in patterns of investment. Of particular relevance in this discussion is the challenge to existing organisational and managerial structures in manufacturing. It can be argued that changes in the environment—with fragmenting markets and shifting demand patterns—became increasingly mismatched with the rigid organisational structures and practices associated with mass production.

This is a theme also taken up by Piore and Sabel who see the running down of the mass production paradigm.[2] Their argument is that as patterns of demand become increasingly fragmented and emphasis shifts to non-price factors, so the necessary industrial flexibility can no longer be offered by mass production systems.

"*Mass production offered those industries in which it was developed and applied enormous gains in productivity—gains that increased in step with the growth of these industries. Progress along these technological trajectories brought higher profits, higher wages, lower consumer prices and a whole range of new products. But these gains had a price. Mass production required large investments in highly specialised equipment and narrowly trained workers. In the language of manufacturing, these resources were "dedicated"; suited to the manufacture of a particular product—often, in fact, to make just one model. Mass production was therefore profitable only with markets that were large enough to absorb an enormous output of a single standardised commodity, and stable enough to keep the resources involved in the production of the commodity continuously employed.*"

At the same time, the newly emerging industries of computers and industrial automation of the 1950s have now matured to the point where information technology (IT) offers a pervasive, low cost resource which has extremely wide potential applicability. Close behind IT are both bio-technology and new materials technologies, whilst in the longer term the emerging industries of the 21st century may well be associated with developments in space exploration (including new manufacturing techniques). It is a central feature of such technologies that they offer opportunities not just for doing what we have always done a little better (substitution innovation) but also for doing things in totally new ways. In the process they shift emphasis from narrow concerns with improving *efficiency* in one functional area of manufacturing to improving the overall *effectiveness* of the business. Exploiting such potential, especially when offered by increasingly integrated technologies, depends critically on developing an appropriate institutional framework. (Appendix 1 provides a more detailed treatment of this argument) (not printed).

If we accept the idea of a new "techno-economic paradigm" in which the rules of the game are changing, then those firms and nations which are best able to adapt, both through adoption of new technology and through innovation in organisation and management of manufacturing, will obtain competitive advantage. It is not, in my view, a coincidence that the country which has made such remarkable progress in manufacturing in the past thirty years—Japan—should also have made the most progress towards an alternative approach to these issues.

Thus the challenge now facing UK manufacturing is not just the traditional one of improving its record on the adoption and implementation of technology but also the need to make radical changes to its operating structures and practices. Competitive success in the future will depend as much on organisational innovation as it will on technical.

ANALYSIS

Given this background, what are the obstacles and stimulii for change in the UK context? I should like to separate these into two groups relating to factors internal and external to the firm. The bulk of my research has been of a micro-economic nature, concentrating on the individual firm and the comments which follow reflect that perspective.

Perhaps the key theme here is *short-termism*—the inability to take or pursue a long-term strategic view or to appreciate that the environment is changing and the new rules of the game may now apply. This well-known and often discussed problem appears to pervade most aspects of the external environment—the financial system, the education system, the activities of government in promoting innovation, the operation of the labour market, and so on. Rather than rehearse this discussion again, I should like to add a few comments related to specific firm-level issues.

(I) The financial system

In the case of the financial system, the question of a lack of understanding of manufacturing and the nature and role of technological innovation amongst members of the financial community (inside and outside the City) must again be raised. My comments here are based upon Anglo-German comparisons (and a more detailed review of these appears as appendix 2) (not printed). The history of banking in the two countries has been very different and an important consequence is that the typical German bank offers a far more broadly based set of services with less specialisation than its UK counterpart. The separation, in the UK, into general (High street) banking and specialist activities by the merchant banks and the City have led to a divide at the level of branch banking between the sector and its industrial customers. At the heart of this is a basic lack of understanding of the perspectives on both sides; industrialists still fail to appreciate the ways in which bankers view the world and bankers, in turn, lack an appreciation of what manufacturing is about and what investments in technology—particularly those of a strategic nature—may contribute to the business.

Manufacturing innovation is mostly made up of incremental developments and investments rather than glamorous high technology leaps—and so the contact between individual firms and the financial community is often more likely to involve the local bank manager than the City. It is at this level that significant differences between the UK and the Federal Republic of Germany show through. Whereas the UK manager has limited experience of manufacturing and inadequate tools for making analyses of investments involving technological change, his German counterpart is likely to have a much deeper understanding of and involvement in the manufacturing businesses in his area. This will extend to an appreciation of the strategic direction which the firm is trying to take and an understanding of the role and significance of technological innovation in that process. Perhaps most important is the high degree of trust between the two, to the extent that the banker's advice is often sought in developing the business strategy.

The problem is compounded by a lack of both language and tools for aiding this process; for example, a typical branch manager of a bank will have little beyond financial measures to guide him/her in their assessment of an investment case. Yet in a changing environment, characterised by new technologies which offer many intangible benefits and which may be of crucial long-term strategic importance but hard to justify in the shorter term, bankers need a much clearer foundation on which to base their lending decisions, and one which incorporates some element of non-financial assessment.

This presents a rather crude picture, but repeated surveys confirm that the relationships between the financial community in countries like Germany or Japan are much closer—and, perhaps more important, are seen as being based on some form of *partnership*. The dominant culture in the UK still seems to be one of confrontation, with negotiation based on an adversarial "win/lose" view of possible outcomes.

Amongst actions which can and are being taken by the financial community have been the training and development of a broader set of skills amongst branch managers through formal training inputs and through job rotation and secondment to provide greater industrial experience. Some efforts have also been put into the development of non-financial assessment techniques and to the creation of specialist units to support the local manager in assessing strategic investments in technology.

(II) Education

A second area of concern is in the education system where, once again, there has been extensive discussion and debate. The problem of attracting young people into manufacturing—and, having got them, retaining them—is going to be one of the key questions in the 1990s as the demographic problem worsens with regard to the availability of young people. In addition, urgent attention is needed to the problem identified by Professor Prais, amongst others, of the poor levels of vocational qualifications in the workforce relative to our European and international competitors. The lack of a continuous supply of trained personnel at a time when emphasis in manufacturing is shifting from capital intensity to a combination of capital and skilled knowledge may prove to be a serious barrier to the UK's ability to remain competitive.

Rather than rehearse this discussion, I should like to concentrate on one area in which I am directly involved—that of management education. As recent reports (such as by Constable and Handy) have highlighted, the general level of formal qualification amongst UK management is very low. For manufacturing industry this is even more serious because the majority of those few managers who do have a formal qualification have been trained in general management (for example on MBA courses) which tends to emphasise financial and marketing aspects at the expense of manufacturing or technology. The consequence is that, at a time when the importance of manufacturing is again being recognised, and when new technological fields are opening up which may dramatically shift the balance of competitive power, the UK is reliant on a relatively unskilled and unqualified group of managers.

There is thus an urgent need for extending the range of provision of education in technology management. Our understanding of the process of technological innovation is considerably better than fifty years ago but a major difficulty remains in transferring knowledge gained through a variety of research programmes into management practice. Recent initiatives, for example, from the ESRC and the Joint Committee of the SERC and ESRC have both focused on the successful management of technological change and have yielded valuable insights into the workings of the process. But unless such knowledge can be transferred into management practice, the exercise will have been of limited value.

There are signs that management education is beginning to shift in this direction, with the reconfiguring of MBA courses to embrace more technology-related streams, the provision of industry-led courses such as the Integrated Graduate Development Scheme (which involves some technology management within its broader, technology-related remit) and the development of specialist courses in Technology Management such as the joint MSc programme at Brighton Polytechnic/Sussex University. The activities of bodies such as the JUPITER Consortium (Joint Universities, Polytechnics and Industry Education Research) are also playing an important role in this process.

(III) GOVERNMENT POLICY

Traditional policy measures for the promotion of innovation emphasise financial criteria and are often general rather than specific in their focus—something of a blunt policy instrument. However it is increasingly recognised that some kinds of industrial innovation may be less sensitive to this type of generalised scheme which essentially operates by altering relative prices, whether by the tax, tariff or other system. Rather the need is for a blend of information, advice and support to the organisation in its learning to make better use of new technological and market opportunities. Only when in possession of this information can the industrialist really make effective judgments about particular investments and their costs.

In particular, bridging the gap—between incremental, substitution innovation aimed at "doing what we've always done a little better" and more radical innovations aimed at improving flexibility and agility within the firm—may need alternative incentives. Such an alternative approach characterises a number of policy initiatives which grew up in Europe during the late 1970s and early 1980s in support of major technological changes such as microelectronics. Here it was recognised that a strategic challenge lay in adopting these technologies as rapidly and as effectively as possible—but at the same time it was also recognised that such technologies lay outside the range of experience of all but the largest and most technologically sophisticated firms. There was a significant gap—in skills, in awareness of particular opportunities for applying the technology, in project management and so on. This prompted a shift away from direct support (by loans, grants, etc.) for investment in fixed assets to programmes which encouraged awareness raising and exploration, and provided a variety of advice and consultancy input as a pre-requisite for investment decision-making.

Schemes of this kind have been operating for around 10 years and have been the subject of a variety of monitoring and evaluation exercises. Most schemes have four basic components:

(i) A general scheme for promoting awareness of new technological opportunities and for publicising the strategic challenges and the need to change.

(ii) a process of what can be termed "innovation consultancy", whereby the individual firm becomes aware of the specific opportunities for applying this technology in its particular context. This involves a process of auditing and analysis within the firm and is often facilitated by an external agent who plays a role analagous to a general family practitioner in the medical world.

(iii) A process of specialist consultancy, in which opportunities identified in stage (ii) above can be explored systematically in the context of a feasibility study. This results in the generation of useful and specific information on which to base decision-making about future investments in new technological areas. It is carried out by specialist consultants—extending the medical analogy above, these would correspond to the hospital specialists able to provide detailed diagnosis and treatment.

(iv) Some form of investment assistance for hardware and "software" including training, skills acquisition and organisational development. Justification for such support is derived from the general and specific information collected in stages (ii) and (iii) of the above process.

Such schemes have been demonstrably effective in:

- Promoting the adoption of new technologies across the economy as a whole and particularly in those sectors or firm size brackets where innovation might otherwise have proceeded only in limited form.
- Promoting the adoption of particular types of technology or application (including "soft" technologies such as design or quality management).
- Mobilising national resources on the supply side, able to provide the variety of consultancy skills needed for specialist and generalist advice.

Although such schemes often include some form of grant, loan or other incentive of a financial nature, the main policy intervention has been to focus much more attention on the awareness and exploration stage of the innovation process. That is, they are concerned with helping develop both general and firm-specific awareness about threats and opportunities in the technical and market environment, with identifying opportunities for exploiting new technology in the context of the existing business, and in establishing a strategic framework (highlighting priorities, long-term development of technical capacity, skills acquisition, etc.) in which such innovation can take place.

In this respect the UK has to some extent been a pioneer, shifting its policy framework away from simply providing financial support to a broader package. This process appears to have started with the 1978 Microelectronics Application Project and related schemes which introduced a formal consultancy stage. It blossomed during the early 1980s when considerable resources were devoted to the active promotion of manufacturing innovation, although subsequent policy has been to reduce drastically the amount of financial support for major investment, retaining only the consultancy and awareness schemes within the "Enterprise Initiative".

Evaluation of such programmes has generally been positive. In our own work reviewing the MAP scheme and, more recently, the FMS scheme, the general industry view was that the schemes had been of considerable value in moving firms into new technological fields much earlier and in a more extensive fashion than they might otherwise have done. Of particular significance is the point made in many cases that the DTI support was primarily in getting firms further up the learning curve and faster with regard to these technologies. One of the features of the new manufacturing paradigm is its emphasis on organisational learning, and any activity which can promote this capacity is to be encouraged.

Although such policy has largely been positive in its impact it is of concern to see the reduction in direct financial incentives in recent years. Much can be done within factories through a reappraisal and the adoption of new manufacturing techniques such as "just-in-time" manufacturing and "total quality management". However the firm will eventually reach the point where it needs to invest substantially in computer-integrated manufacturing technology and it is at this point that long-term strategic considerations become important. Under current payback expectations, few firms will be able to undertake the investment they require to exploit the technology fully; this is especially a problem for smaller enterprises. The value of government support in helping firms enter earlier and more extensively is considerable—for example, the Small Engineering Firms Investment Schemes of the early 1980s were a very powerful lever to enhance the competitiveness of smaller firms through enabling them to move into the use of computer-numerically controlled machine tools. Without such schemes it is questionable whether a sufficiently strong engineering base can be counted upon in the future.

Internal factors

In many ways the problems within firms mirror those already mentioned in the external context. Once again there is the problem of a short-term view, of a pre-occupation with "getting the product out of the door" at all costs—an attitude which leads to a perpetual state of crisis management. Manufacturing is not seen as a strategic issue (a point made well by Terry Hill,[3] amongst others) and as a consequence decisions about innovation in manufacturing tend to be taken with little or no reference to any long-term strategic framework. This places emphasis on short-term improvements in efficiency within narrowly defined areas and militates against longer-term actions which might enhance the overall effectiveness of the business.

A second, central point is that the exploitation of new opportunities in technology depends critically on parallel organisation changes. The lesson now being transferred from Japan to Western firms is that some form of synchronous innovation along both dimensions is needed. Appendix 3 presents a review of the kinds of change required in greater detail (not printed).

(I) The financial system

The pattern is reinforced by the financial appraisal system which operates in most UK firms which expects a short-term return on investment and does not allow much scope for so called strategic investments. One of the big difficulties in considering a *strategic* investment is that it is essentially for the longer-term whereas most investment appraisal systems deal with much shorter time periods. For example, CIM-type systems will require long time periods for payback, often five years or more, whereas the average expectation under normal circumstances in Western industry is two to three years. The result is that investments are either justified on the basis of figures force-fitted to traditional formulae—or else not justified at all but entered into as an "act of faith".

The argument is about two aspects of accounting—how to justify investments and how to account for them in day-to-day operation. In the former case, there is a need to find ways of building in "intangible" stategic items into the appraisal—for example, the cost of not being flexible in response in the market place in five years time. Emphasis is shifting, following the Japanese example, to consideration of non-financial criteria where "factors such as desired market share, cycle time, reject rates and innovation are given more weight in managerial decision-making than calculative exercises about financial viability". Rober Kaplan cites the case of Yamazaki in Japan, one of the most successful machine tool builders in the world which has pioneered the use of FMS. Its Mino Kama plant cost $18m in the early 1980s and produced extremely good results in terms of lead time reductions, space savings and inventory savings. However, despite these its return on investment over the early years of operation was only 10 per cent—and it would thus have been rejected by most US or European firms as a poor investment.

Kaplan makes the point that ". . . most of the capital expenditure requests I have seen measure new investment against a status quo alternative of making no new investment—an alternative that usually assumes a continuation of current market share, selling price and cost. Experience shows, however, that the status quo rarely lasts. Business as usual does not continue undisturbed." The need is for a new approach from the financial accounting community—but, as in so many cases, there is considerable inertia and commitment to established procedures. He sums up the problem succinctly when he suggests that "conservative accountants who assign zero values to many intangible benefits prefer being precisely wrong to being vaguely right!"[4]

In the UK a number of commentators argue that alternative bases of justification can be used which allow for a shift away from traditional savings to those of better quality, delivery and shorter lead times. They have even developed computer-based systems for helping firms in their investment appraisal but this has not yet diffused widely and most UK firms still rely on traditional (and often inappropriate) techniques for investment appraisal.

The industry-based organisation, CAM-I, commissioned a major study on accounting and AMT and found that in investment appraisal, most firms still considered intangibles and qualitative benefits only marginally after looking at direct labour and materials savings. Firms in the sample also tended to look for payback in less than three years.[5] Another study, carried out by the Centre for Business Research in 1988 of 106 UK companies found, more optimistically, that 87 per cent attempted some form of inclusion of intangible benefits.[6] However the sophistication of techniques for doing this was very limited; 55 per cent of firms used only one method of appraisal and only a handful of firms used more than three methods. Clearly there is a greater chance of useable estimates if more than one method is used to quantify intangibles.

Increasingly there is a trend towards involvement of more than one department in the appraisal process, reflecting the broader impact which AMT can be expected to have. In the survey 42 per cent used some form of group discussion to enable them to generate data on intangible benefits, whilst a further 35 per cent used a detailed study rather than simple cost estimation techniques.

Some firms have begun to develop alternatives. For example, Cummins Engines in the USA installed a new flexible machining line for a brake product in 1985. It was at that time looking for new products and markets to offset a maturing of the diesel engine business. They placed a premium on flexibility such that although the cost of a flexible line was two to five times higher than a similar dedicated plant would have been, the tooling would be two to three times cheaper to change. In the event the return on the investment was over 40 per cent, largely because of the inherent flexibility to switch to other products.

In the area of production cost accounting one of the problems is the obsolescence of accounting ratios. Traditional indicators such as standard hours produced, tonnes produced, machine utilisation or labour efficiency are now no longer relevant—for example, because of the decline in direct labour or the emergence of just-in-time principles which would argue against using machines unless they are producing something which is actually needed. Instead of traditional costing based on allocating charges to particular machines or operations, some form of flow accounting based on throughput or total factory performance is being preferred.

(II) Skills and training

Further reinforcement of the short-term problem comes as a consequence of the lack of investment in skills development and training. As has been widely reported elsewhere the UK has a very poor record on skills at what Prais terms the intermediate level.[7] For example, in comparison with West Germany only about one third of our workforce possess intermediate level vocational qualifications whereas in Germany over two-thirds are so trained. The traditional excuse offered by British industry that it will not invest in training because workers so-trained will then be "poached" by other firms is symptomatic of the short-term view discussed earlier and it also reflects a preoccupation with training as a "cost" item, rather than as an investment for the future. Such under-investment in skills—whatever the cause—may represent a serious threat to our ability to exploit new opportunities in manufacturing technology since these will be critically dependent on the availability of trained and flexible human resources.

In the area of skills, three broad changes can be identified. The first reflects a structural shift towards higher levels of skill required to support increasing complex technologies. Data exists for a variety of industrial sectors and countries to confirm the general observation that there is a decline in the number of unskilled and semi-skilled workers in manufacturing and an increase in the requirement for professional engineers, technicians and similarly qualified staff.

This is not only a function of the changing technological and employment pattern, it also reflects the changes in the educational expectations of individuals who are now more conscious of the need for higher levels of qualification and who express a desire for greater personal development.

The second trend is towards greater convergence, with the shift from single skills towards multiple skills, required to support increasingly integrated and interdependent technologies. This process has been observed across a wide range of occupational groups and at all levels in the organisation.

The third trend is towards greater flexibility of deployment. Whereas traditional models involved clearly defined, predictable and pre-determined tasks for which single skills could be developed, the emerging pattern is one which demands a more flexible response. The key skill here is the ability—or agility—to switch in different skills as and where relevant. For example, the task of maintenance is becoming more and more dependent on diagnostic and fault-finding skills, which require considerable flexibility and creativity, and correspondingly less so on actual repair skills.

An indicator of this is the emergence of new job titles and descriptions. For example, in the vocational education system in the Federal Republic of Germany a number of new Berufe—occupations—have been developed to reflect the skill needs in advanced manufacturing. Ettlie reports on similar patterns in the USA.[8]

One consequence of this greater reliance on multi-skilled and flexible support in AMT is the greater emphasis which it places, of necessity, on training and development. Whereas traditional models involved the acquisition of a single skill which would be applied throughout an employee's working life, the emerging pattern is one in which skill often have a short life cycle and where the skill in acquiring new skills and updating old ones becomes critical. Such "learning to learn" depends principally on developing an understanding not only of "know how" or "know what to do" but also of "know why"—a gradually deepening understanding of the broader context in which the worker is operating. This in turn moves the emphasis from task-related training to individual development, and from being a cost related to a particular piece of new technology and towards being seen as an investment in organisational capability. Tacit knowledge and the ability to acquire and dispose skills in flexible fashion will become increasingly important factors in getting new technology to perform effectively, and many firms are now beginning to recognise the advantages offered by becoming a "learning organisation".

The notion of strategic choice can be seen clearly in the case of skills. There is no longer any technological imperative which argues for a particular level or disposition of skill but rather a range of choice open to managers. Whereas earlier systems emphasised deskilling and the removal of operator control and discretion, much of the current trend is in the reverse direction, in which human operators are seen as a key adjunct to successful implementation and flexible operation of advanced systems.

(III) WORK ORGANISATION

Closely linked to the skills question is that of work organisation—how people are used in the context of new technological systems. Here the traditional mode in the UK has been to try and eliminate labour from the shopfloor and to automate out many skilled tasks. Evidence is growing, however, to suggest that a key feature in future manufacturing facilities will be that they are modulated by highly flexible and multi-skilled staff. The degree to which UK firms are able to exploit such technology will depend on how far this model can be reproduced in British factories—and this, in turn, depends upon the level of skills available and the willingness of management to take a different approach to work organisation.

Moves of this kind may appear technologically necessary but they often challenge the basic structure of organisation within old-established plants. For example, in the Shell Chemicals plant at Carrington, Manchester, a new agreement has abolished the original structure consisting of 14 craft trade groups (like laggers, welders, plumbers, etc.) and replaced them with a single grade. All non-management personnel, including clerical and catering staff are now classified as "technician" and the pay system has been massively simplified. In order to provide the necessary skill mix extensive redesign of jobs took place and heavy investment of training has been made so that every plant technician will be sufficiently skilled to handle about 80 per cent of traditional craftsmen's work across all traditional trades.

This change towards more flexibility requires a major strategic commitment on the part of the organisation to change. As the Personnel manager explained:

> ". . . we'll manage flexibility in future . . . we are determined not to slip back into allowing people simply to do what they feel comfortable doing. It's one bargain, one code of working and everybody does everything which their skills and knowledge allow them to do safely. Cultural and attitude changes are required".

(IV) Technical progressiveness

The issue of technical progressiveness has been the focus of research for over forty years, and it is worth summarising the key features of such firms, not least because these factors *still* emerge regularly as influential in the innovation process.[9]

High quality of incoming communication.
Deliberate survey of potential ideas.
Willingness to share knowledge.
Willingness to take new knowledge on licence and to enter joint ventures.
Readiness to look outside the firm.
Effective internal communication and co-ordination.
High status of science and technology within the firm.
Consciousness of costs and profits in R&D.
Rapid replacement of machines.
Sound policy of recruitment for managers.
Ability to attract talented people.
Willingness to arrange for the effective training of staff.
Use of management techniques.
Identifying the outcome of investment decisions.
High quality in the chief executive.
Adequate provision for intermediate management.
Good quality in intermediate management.
Ability to bring the best out of managers.
Use of scientists and technologists at board level.
Readiness to look ahead.
High rate of expansion.
Ingenuity in getting round material and equipment shortages.
An effective sales policy.
Good technical service to customers.

Central to this set of factors is the role of management and, as indicated earlier, one of the key challenges in manufacturing innovation in the future will be how to make UK management more technically progressive. There are clear structural and procedural changes which need to be made—adoption of a longer-term strategic framework, revision of financial appraisal and management systems, investment in continuing training and development and revision of working patterns at all levels—but underpinning all of these activities will be technically progressive management. The question then becomes one of whether you believe that good managers are born or made; not surprisingly, in view of my Business School background, I subscribe to the latter view. Managers create organisations and systems and it is primarily through them that the necessary changes to enable UK plc to capitalise on the technological opportunities of the "fifth wave" will be made. This places considerable emphasis on the need for much greater emphasis on management training and development and the transfer of our knowledge of factors affecting success and failure in industrial innovation into practice through technology management training and development.

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Memorandum by BICC Group

(A) EFFECTIVENESS OF UK COMPANIES IN SEEKING OUT AND ADAPTING EXTERNAL TECHNOLOGY

Japan has had success in this area with some 30,000 separate agreements signed to spend $10bn over the period 1950-80 to secure necessary foreign technology.

Japanese companies take "technology watching" very seriously and spend substantial sums on overseas offices, sending key staff on overseas postings, information collection (technology and markets) and competitive assessment, licensing and speed of adapting foreign ideas, market trials, investments in key foreign universities.

Companies having laboratories in Japan have found that this is a good source of technological intelligence since the laboratory is "plugged-in" to local networks (ICI are pleased with the effectiveness of their new Japanese laboratory). For the many companies that cannot afford this, both encouragement and government help (a modest DTI scheme?) to emulate Japanese companies' overseas activities would be worthwhile. The UK has a relatively low level of payments to other countries for patents, licenses, etc., and could take more advantage of such arrangements.

(B) RESPECTIVE ROLES OF PRODUCT AND PROCESS INNOVATION

Quality and low cost, efficient manufacturing to best demonstrated practice are becoming recognised as the entry tickets to global competition (and there is still some catching-up to do in the UK in these respects). However, it is factors such as new and improved product innovations, speed of product development and the ability to produce good product variants quickly that are increasingly providing competitive edge. Some Japanese companies are particularly good at fast track product development and in completing all engineering changes before product launch. Effective interfaces between R&D/Marketing/Manufacturing are important for this as is good market information (see (a)). These interfaces are improved by attention to training, staff development, exchange of staff between functions.

Some European companies are now emphasising a two-stage innovation process. Phase one is the first and smaller (elite staff, innovative climate, options considered, "informal" organisation) leading, after R&D/Marketing have an agreed approach and a "go" decision to phase two (tight, well-defined programme, fast and ruthless, right first time, very early involvement of suppliers and manufacturing in "simultaneous engineering") which leads to early product launch.

(C) EFFECTIVENESS OF GOVERNMENT DEPARTMENTS IN PROMOTING INNOVATION

The DTI "support for innovation" programme of the early 1980's has been reduced to a smaller number of modest collaborative programmes under the research and technology initiative and is minor compared to the European Commission R&D programmes. The recent CBI report highlighted the problems of "protracted grant negotiations" and delays between submission and approval. There is a strong case for the smaller DTI collaborative programmes seeking to differentiate themselves from the larger CEC R&D programmes by emphasising flexibility and rapid decisions for a few key technical areas (see also (A)).

Given the global emphasis on speed of innovation (see (B) above), it is important that government schemes to support collaborative R&D and innovation are characterised by quick response, flexibility and rapid decision processes.

The DTI "LINK" programme was introduced to encourage co-operative R&D between industry and universities. The principle is good but the programme unfortunately includes implicit financial penalties for companies proposing a substantial university involvement. In practice, if there is minimal university participation, DTI support for the industrial members' project work is almost 50 per cent but, if university participation reaches one half of the project, DTI support for the industrial project work falls to zero. The LINK programme therefore does not compare well either with European Commission programmes or with non-LINK UK projects where SERC fully supports a university project and the DTI supports a collaborative industrial project in a related area at 50 per cent.

The LINK scheme therefore needs to be revised to provide 50 per cent support for collaborative industrial work while retaining SERC support for the university components. This should help reduce the current DTI underspend on the LINK scheme.

(D) City attitudes to investment in innovation

A copy of the paper on "Long Termism" by Richard Freeman, Corporate Chief Economist of ICI plc is attached (not printed). This distinguishes between "developers" and "franchisers" amongst major British companies. The "developers" (some 25 major UK companies) are the ones that sustain long-term R&D costs, train technological staff, cross-subsidise R&D between businesses and are active across the spectrum of R&D. "Developers" make a major contribution to UK exports and contribute to growth. Freeman suggests that some 20 or so developers account for about 75 per cent of total UK civil R&D. These large companies also act as centres around which smaller companies and suppliers are often involved in collaborative projects. DTI involvement with UK "developers" is clearly important and could parallel some of the positive activities of MITI in Japan. Richard Freeman points to the attractive short-term gains to be made by turning a UK developer into a franchiser for an overseas developer; the consequence would be that UK plc suffers. Freeman feels the city takes an insufficiently long-term view of UK "developers" activities.

(E) Technology transfer from HEI's, Research Councils, etc.

While further transfer of technology from universities and public laboratories is worthwhile, it is no substitute for an adequate level of R&D in manufacturing industry (note that, in Japan, the majority of R&D is performed by manufacturing industry). The tax and regulatory environment should be set to favour this.

The LINK scheme needs to be revised to encourage further co-operation between industry and HEI's in selected areas (see comments in (c) above).

A major factor governing innovation in the UK is the supply of good graduates and trained researchers (via higher degrees) and hence the quality and international standing of HEI research departments and personnel. Co-operative schemes such as CASE awards and Total Technology are important in encouraging university/industry links and a flow of trained R&D people into industry; it is important that SERC stipends for such schemes are set at realistic levels.

(F) UK benefit from EC support

The UK has benefitted surprisingly well in the past. The EC also seem to be taking a much more flexible interpretation of "pre-competitive". However, given that EC funds only go to collaborative projects, companies with substantial UK laboratories are most easily able to access these funds. There is a concern that UK private sector R&D laboratory manpower has been reduced over the last few years in a number of companies and that this may reduce the future UK share of EC R&D funds.

The Commission are receptive to well-presented cases for new R&D support. For example, BICC with a number of other European construction companies is currently pressing a case for more EC support for R&D in construction (an area where any one of the five major Japanese construction companies spends more on R&D than all UK construction companies together). There is an opportunity during 1990 for UK companies to influence the EC on the content of the new Framework "R&D" programme to ensure that this contains additional technical areas and improved priority themes for R&D. The additional 5.7bn ECU granted for the new "framework" programme (over and above 3+bn ECU remaining from the existing framework programme) is welcomed.

(G) Relationship between defence and civil sectors

For companies such as BICC plc, the large UK defence R&D spend has negligible benefits and it is the total UK civil R&D spend that should be used in comparing the R&D performance of UK plc with our competitor countries.

Experience with DTE (Defence Technology Enterprises) indicates that technology transfer opportunities from defence R&D establishments to UK companies are very limited.

(H) Innovation award

The importance of innovation for the UK might be recognised by an annual innovation award. This could either be a new scheme open to UK companies or incorporated into the existing Queen's award scheme which at present emphasises technology and exports.

Memorandum by BP

1. Company attitudes and structures

Company attitudes to innovation are very important. An organisation which fosters a climate where innovation is encouraged, funds the effort needed to generate innovative solutions, new products, etc., and is not disillusioned by the inevitable failures of what is a risky process, will be well-rewarded with a steady stream of new products, processes, and techniques. These are essential ingredients in maintaining and increasing competitive advantage. Conversely, an organisation which distrusts the innovation process, and fails to encourage it, will progressively become less competitive. Apart from the absence of new products, one of the most serious effects of a negative attitude is the loss of bright, imaginative, and highly-motivated staff on whom the future well-being of any business depends.

So why are high levels of innovation not paramount in all companies? Put simply arguments of economy of scale of production dictate ever greater product standardisation and more streamlined production and this reduces the capacity for innovation. An organisation designed to efficiently produce the millionth car or serve the millionth client is not good at doing something for the first time. Radical change in the eyes of an existing manufacturer is competitively dysfunctional. To combat the "corporate immune system" the organisation must develop a structure which allows new products and processes to flourish whilst maintaining profitable existing businesses. Experience within BP would suggest the following are important:

— An organic, adaptive, risk-taking organisation which experiments in the marketplace as well as the laboratory.

— An outward-looking management style aimed at finding a coincidence of purpose with customers, partners, and suppliers.

— Simultaneous coupling of innovative ideas in a multi-disciplinary team (incorporating development, production, and marketing skills) focused on a common goal.

— A close interaction with the research function which acts as a reservoir for people and ideas.

— Utilisation of staff in key roles such as product champions and market/technology information gatekeepers.

— A high level of operational autonomy within the teams but with innovation systemised through milestones/report cards:

— A reward system which is geared to high levels of achievement but with a human resource planning system capable of coping with the problems of product failure.

— A long-term commitment to fostering innovation but a culture which enables a rapid and flexible approach to the pursuit and abandonment of opportunities.

— An "organisational champion" at senior level who provides a single point responsibility for management of the innovation process.

— Mechanisms within the organisation for product take-up by business units.

— A value-based planning approach which adequately balances long-term potential against short-term profitability.

We perceive that a significant problem for innovation within many British companies lies with the economic returns expected. Any project would normally be expected to have a real rate of return of, at least, 10 per cent. By contrast, many of our overseas competitors would be happy at five per cent or less over, say, a seven year timeframe and would take strategic position for a later timeframe into account. One result in the UK is frequently that to improve the financial picture necessary resources are not devoted in the development stage—and the need for these resources may even be hidden by development groups. Market forecasts may be inflated to provide suitable returns. Disenchantment and project abandonment frequently follows when the truth sinks in—all in response to applying conventional economic analysis to innovation.

People are the key to innovation. Innovation is a risky business and many ideas will fail. This must be expected as an integral part of the dynamics of the learning process. However, the personal risk to staff who are adventurous and prepared to try something new must be minimised. A reward system which motivates innovative behaviour must take account of the higher risk, greater difficulty and longer timeframe of product/process developments compared with normal operations. Cultural factors, flexible management structures and working groups, and financial incentives all are important in setting an innovative climate.

2. Technology: create or buy?

Clearly the answer is do both. A successful manufacturing business needs a strong in-house technology resource base which is directly tied into meeting business goals and providing a means for technology transfer. However, this same resource base should also provide a window on external technology since no company has monopoly on new ideas. Within the past few years, BP has acquired several technologies, notably from US, Germany and Australia, to complement in-house skills and technologies and to provide business advantage. Once acquired, the issue is where to carry out further development and commercialisation. Usually the solution is near to the company's existing manufacturing sites and/or markets but this requires sensitive handling of the all important technology transfer activity.

3. Role and product development and process engineering

Successful product innovation demands:

1. *A sound technology base,* which may include such aspects as control over material availability and properties and cost.
2. *Suitable processing skills* to enable the product to be manufactured efficiently.
3. *The market need* for the product with customers who are prepared to pay an economic price.

The trigger for innovation may arise in any of these three elements but all must be satisfied before innovation is successful. (It is noticeable that the third element is not touched upon in the Select Committee on Science and Technology Sub-Committee's invitation of 31.1.90).

During the process of innovation it will never be entirely certain that each of the three elements—technology, processing and market need—can be met. The prospects in each element must be subject to ruthless probing. Real problems must be ironed out whether in the mainstream of development or in increasingly pressing issues such as health, safety and environment. Testing to provide the necessary information may be lengthy—particularly where the ultimate product must have a long lifetime. Competition will emerge which must be assessed and responded to. Market situations may change—positively or negatively.

Innovation is thus a lengthy process—which may be two years for a "small" innovation to ten years or even longer for a major step. Within the timeframe management and/or management aims will alter; ownership may be transferred; champions and adversaries will appear and disappear. Lengthy processes dictate expense and the sums involved in innovation can be substantial in the case of a major innovation, particularly in the later stages where capital investment in production facilities would usually be required.

Production engineering can also be innovative, and when innovative product development is matched by innovative engineering, great success can be achieved. Similarly, the availability of sound production engineering can make or break otherwise brilliant new designs—if you can't make it at a price the market is willing to bear, it won't sell. However, it must not be assumed that an optimum mix of technological innovation and "sound" engineering will happen automatically. Imaginative new initiatives which are not matched by appropriate engineering responses run a high risk of failure.

Additional to technology development and production engineering, the role of marketing demands consideration. It is a foolish company indeed which denies the primacy of the customer. Technology push alone is usually doomed to failure. Rather there is a need to couple all three elements—technology, processing, and marketing—within the organisation. Hence the utilisation of multi-disciplinary teams incorporating development, design, manufacturing engineering, and marketing personnel would appear to be the best way forward. There is considerable evidence for the use of a multi-disciplinary team approach in those companies whose success depends on the continual generation of innovative new products.

4. Role of Government Departments

Government funding of innovation can be helpful and it can be particularly welcome for smaller companies which may be less able to bear the financial risk of breaking new ground, although such firms may be more able in other ways to undertake new departures. However, such help must be available with a minimum of bureaucracy; firms generally, and small companies especially, cannot afford to devote the substantial resources often required to comply with funding agencies' procedures. Overall, despite the importance of finance, innovation is only likely to succeed where there is a positive attitude throughout the company, and it may be that Government can play a role in educating managements and helping to build confidence and trust in the innovation process.

On the world scene, Governments also have a role in establishing and utilising major generic technologies. In two areas of interest to BP, advanced composite materials and photovoltaic energy systems, we note that the US, Japan and several European Governments are committing at least an order of magnitude more resources to their national industries than in the UK. However, perhaps even more important than the relative size of the budgets is the way in which much of the overseas funding is being spent. Specifically, Governments are providing funds to enable companies to develop manufacturing engineering aimed at scaling up production, reducing units costs and improving product quality, and to work with customers to evaluate and qualify products, in addition to the more familiar role of funding "front-end" pre-competitive R&D. This is, in effect, a major subsidy. Unless appropriate responses are made by the UK, our perceived national trait of being strong on invention but weak in engineering and commercialisation of products is likely to increasingly become a reality, especially in those technological areas where high levels of investment and long timescales to realisation are the norm.

5. City attitudes

Clearly it is for companies to convince the shareholders of the value of their business strategy and associated resource allocation.

The effect of city attitudes to investment in innovation is principally indirect—encouraging short-term approaches, via expectations of rapid returns on investment, from company managements.

Government support through incentives for investment in R&D and achieving a lower interest rate economy would be beneficial.

6. Regulatory framework

Tax concessions on R&D expenditure represent the most direct and valuable support Government can give to innovation. Such concessions will tend to cushion R&D from cutbacks when the economic cycle is on the downturn, i.e., when fixed costs such as R&D are under scrutiny in an effort to maintain company profit levels. This can help R&D being correctly perceived as an investment, rather than a cost.

Regarding patent law, we support the initiatives to harmonise the procedures and legal framework internationally and hope they can be expedited.

7. Technology transfer from HEIs, etc.

Successful technology transfer from HEIs, public laboratories, etc., to manufacturing industry is difficult to achieve. Fundamentally, the concept of a rapid linear transfer process from science into commercial use is flawed. Rarely do we find new science producing a body of knowledge which leads to a state of the art technology development which in turn generates a practical need enabling utilisation. The relatively few examples of "breakthrough" science leading directly to a major commercial impact have a long time lag (often 20-30 years) between discovery and implementation. Conversely the simultaneous coupling model of innovation demands a close interaction between science, technology, and the marketplace, with technology defining problems for science to solve. Hence to be effective, HEIs, etc., must be part of the "team" and technology transfer worked at continually. It is best achieved through movement of people, but where this is not possible, effective transfer can be implemented by pursuing dialogue and, wherever possible, practical collaboration within a framework of shared goals. In BP's research, links to Universities have proved successful due, in considerable measure, to the attention given to establishing strong, long-standing relationships at the working level which form the basis for effective technology transfer.

8. EC support

BP experience of EC support (ESPRIT/BRITE) has been generally positive although programmes are very time consuming to set up. The key requirements for firms are to have a clear view of why they wish to collaborate, to enter into projects with partners with whom they are comfortable, and then to adopt a fully committed approach to the collaboration. Again, technology transfer is very important. Perhaps Government could organise more seminars on how to collaborate within EC programmes successfully? It may be that increased dissemination of information about potential collaborators in other countries and about potential areas of interest would be helpful.

9. CUSTOMER/SUPPLIER RELATIONSHIP

As a supplier of advanced composite materials and other differentiated speciality chemical products, BP has developed strong links with its customers. This is often a prime source of innovation since through understanding the customers' needs, appropriate products can be designed, (i.e., the customer is effectively on the "team"). In the defence area (especially in the US) these relationships are often formalised in development/evaluation contracts funded by the Government which are a critical part of the qualification of new materials and products. In developing such relationships it is clearly important to understand where your competitive advantage lies and accordingly decide your positioning in the value chain; this is particularly important in areas such as composite materials where historical positions based on metals and their well established fabrication processes may be inappropriate.

10. INVESTING IN THE UK OR OVERSEAS?

It is doubtful whether monetary factors such as short-term exchange rate movements influence companies to invest in innovation in particular countries. It would seem far more important to invest where the desired manufacturing expertise resides and/or near to market opportunities. Keeping close to the customer is clearly critical for successful product development. The UK is usually seen as strong on scientific capability but weak on ability to turn innovation into commercial gain. There could be a case for UK companies learning more how firms in other countries profit from innovation and the role of Government in this process.

11. RELATIONSHIPS BETWEEN DEFENCE AND CIVIL SECTORS

BP's experience bridging these sectors is primarily in the advanced composite materials industry which produces products that are either immediately applicable to both civil and defence sectors or are initially targeted on defence sectors where higher prices can be justified at the outset before benefits of scale allow penetration of civil markets. In the case of the UK there is little effective support from HMG for defence applications and none for civil. In contrast within the US we note that:

(a) US Government Agencies recognise that the advanced composite materials field is a major industry of the future and are working to ensure that the US achieves a dominant position. Whether funding comes from DoD or not, it is expected that there will be significant outcomes in civil sectors—particularly in aerospace.

(b) Funding covers all aspects of the development of a particular material often under a single umbrella programme from initial feasibility projects through materials production and demonstrator component fabrication, scale up to fully establish real costs and problems, through real-life fabrication and flight test. In every instant the timescales are understood by all concerned and monies are committed to extents and over timescales sufficient for the purpose of innovation in the field.

In this industry the US Government is most effectively acting as champion, gatekeeper and customer in its attempt to spur innovation.

Memorandum by Britax Automotive Components Division

INNOVATIONS—DEFINITIONS

Technological innovation is the transformation of an idea into a new or improved saleable product or operational process in industry or commerce (OECD 1981).

Find a NEED, then FILL IT! (Pilditch. Marketing 1978)

INTRODUCTION

In preparing a response to the specific questions posed by the Select Committee, I have found it extremely difficult to provide what I would justifiably regard as "evidence", within the strict legal definition of establishing facts.

I have therefore placed the responses into the context of small/medium-sized companies in the Automotive Industry.

Outside the requirements of the brief received from the Select Committee I have included additional points:

- Some notes on the effects of the growth of an integrated worldwide Vehicle Industry on nationally-based innovation.
- As an Appendix, some background data and details of BSG International PLC and its Britax Automotive Component Division operations.

Lastly, in examining my own experience I have come to believe that the range of initiatives created by Government concentrated on the institutional mechanisms, has underestimated the management and human aspects of successful innovation.

I have therefore supplied a simplistic outline of a proposal which I believe could properly be the subject of a new initiative of lasting value to the majority of small and medium-sized companies which make up UK manufacturing industry.

I would also like to acknowledge the help given by my colleagues in the Division, and specifically to:

M Carbonel — Britax GECO (France)
R S Goldsmith — Britax Wingard—UK
A Hollingshurst — Britax Patent Agent.

I hope that the submissions will add light as well as volume to the evidence received by the Select Committee, and that my departure from the strict brief given will be excused.

I K SHOWAN
Divisional Managing Director
15 *June* 1990

EXECUTIVE SUMMARY

Q1 *What are the effects of company attitudes and structures (including personnel policies and investment decisions).*

In the promotion of successful innovation, which in a manufacturing company means not only developing new products and new technology but also the rapid and successful implementation of those innovations, company attitudes and structures both can influence the process of innovation.

They will not, however, ensure effective innovation. Company structures can if over-rigid be an inhibition to rapid development and implementation, but the evidence suggests that successful innovation can take place in companies with a wide variety of organisational structures, both rigid and flexible.

Critical to successful innovation is the creation, within the company, of an environment which accepts and welcomes change as part of everyday activities.

This can be accomplished if the company management as a whole, *manages for innovation* on a consistent basis, by organising and delegating responsibility and authority for initiating and making change effective.

It requires that competence of all employees is increased, and that the risks inherent in change are shared by all levels of the company, and failure used as an opportunity to learn and not attribute blame.

The experience of the Britax Automotive Component Division using this approach has improved our rate of innovation, our basic technological capability, and our ability to gain business.

Q2 *How active are UK companies in seeking out external technology, especially from overseas? How well do they adapt and apply it?*

As part of a multinational group serving the Automotive industry worldwide (see Appendix A) it is essential that we are knowledgeable of the latest developments. Our customers require that we are using the most appropriate technology, and our customer base and its distribution makes us well placed in our ability to keep abreast of developing technology.

We have established both informal links with comparable companies in Japan and the USA, as well as in Europe, and our successful business with Japanese implants in the UK has given us knowledge of Japanese manufacturing and management techniques.

We have as a conscious policy set out to meet all our various customer requirements, and to adapt suitable good practices for our use as a matter of course.

The growing international aspects of the Automotive Industry are resulting in increased co-operation in component supply which is an indirect but effective means of transferring technology, both importing and exporting elements of technology, on shared contracts to supply, and we have successfully adopted many elements to improve our international competitive position.

Q3 *What are the respective roles of product development and production engineering in technological innovation?*

There has been a significant shift in the established relationships of Product Development and Production Engineering, with the sequential "relay race" approach of Product Design, Product Development, Production Engineering Tooling and introduction into manufacture being replaced by Simultaneous Engineering, where all design, planning and tool development takes place concurrently.

The reduction in product life-cycle, the increasing rate of technological change, higher expectations of quality and performance from first production, the increasing complexity of modern manufacturing methods are all requiring the quality and quantity of pre-planning to rise dramatically.

To achieve the desired rate of innovation against this scenario requires that high quality Manufacturing Engineering skills form an integral part of the Design and Development process, and successful innovation will depend as much on innovation in Manufacturing as in Production Design.

The creation of more adequate resources in the field of Manufacturing Engineering (Production Engineering, System Engineering and Facility Engineering) is an urgent need, as is the development of effective methods of management of innovation programmes.

Q4 *How effective are the activities of Government departments in promoting and supporting innovation?*
The Government cannot influence directly the decision of a company to undertake innovation. A company's decision to innovate has to be made taking into account the company's own definition of the level of acceptable risk, the opportunities/threat which is being addressed, and the available solutions to the problems it faces.

The assistance available under Government initiatives and schemes has been accepted by the Britax Automotive Component Division, but only on a limited scale.

The main factors restricting our use of these schemes have been incompatibilities between our commercial needs and the rules laid down:

- The timing constraints and conditions.
- The insistence that we must show that without assistance we will not proceed.
- The time taken to identify the applicable scheme.

CAD a Specific Case

The widespread introduction of CAD (Computer Aided Design) is becoming essential to compete. Its costs are high and conventional financial justification difficult to make.

This will pose a serious and increasing threat to small companies and there would appear to be a case for specific Government assistance for small companies for whom CAD will be an essential requirement.

Q5 *What are the effects of City attitudes to investment in innovation?*
I am able only to provide general comments, as I have little direct experience on which to draw.

The accelerating rate of product change and the reduction in product life, the increasing cost of the latest technology and the lengthening period between the need to invest and the supply of product in the automotive component industry are all factors which require a longer term view than shown in annual accounts.

The effects of this accelerating rate of investment which are a necessary part of maintaining progress in an international automotive component supplier, places severe strains on capital, particularly in a period of rapid growth, and can present a severe problem to small companies.

This conflicts with the increasingly short-term view which, it is reported, is routinely taken by the City.

As a result, the gaining of a major international contract can have adverse effects on the City view of a company which from any other standpoint would be regarded as highly successful.

This effect can be extremely restricting on small companies' willingness to accept the risks of innovation which will be essential for long term survival.

Q6 *What is the effect of the legislative and regulatory framework concerning for example labour costs, patent laws and Tax concessions on R&D and purchase of know-how?*
The Regulatory and Legislative Framework as it affects the Automotive Industry in respect of the standards of performance, safety and on environmental aspects has a major part of creating innovation in consumer aspects of product development.

The organisation and methods used internationally to implement these regulations do allow for flexibility in detailed test procedures and can be used to block innovation or preserve national manufacturers.

As far as the effects of this framework in respect of labour costs and patent laws and Tax concessions are concerned, I am not aware that these have significant effects on R&D and the purchase of know-how.

Q7 *How effective are the mechanisms for technology transfer from HEI, Research Councils and public laboratories?*
Our experience, whilst limited, has indicated that they are not effective.

From the standpoint of a medium-sized company, it is extremely difficult to discover what work on specific elements of technology is being carried out.

A second constraint would seem to lie in the HEI themselves, specifically in the mechanisms which the HEI put in place to interface with industry.

It would seem that incentives for HEI to accept projects from industry are insufficient, and effective response to an industrial project would appear to depend on the current interests and enthusiasm of individual members of HEI staff.

Whilst there are cases where major industries have developed long-term co-operative arrangements with specific HEI, the response to industry as a whole, and the effectiveness of mechanisms for technology transfer, must be placed in doubt as far as small- medium-sized companies are concerned.

Q8 *Does the UK benefit sufficiently from EC support for innovation? How might it be improved?*
I am not competent to answer, as I have had no direct experience.

Q9 *What are the effects of varying relationships between companies and their suppliers?*
There has been a radical shift in emphasis in relationships of Vehicle Manufacturers and their suppliers.

This change has resulted in a major transfer of Product Development responsibility, previously carried by the vehicle manufacturer to its suppliers, and has necessitated a major change in supplier selection. This has had the effect of:

- Restricting the overall number of suppliers.
- Requiring suppliers and would-be suppliers to prove technical capability in all aspects of Design and Manufacturing.
- Suppliers being required to innovate to remain competitive.
- Requiring suppliers to co-operate in developing technology for supply of a shared contract.

For small companies, these burdens will prove onerous and coupled with the financial aspects (see Q5 response) may prove an insuperable burden.

Q10 *What factors influence decisions to invest in innovation in UK or overseas?*
Whether investment in innovation is conducted in UK or overseas, the factors influencing our decisions are:

- Where the need exists—or opportunity created.
- Where our customers are likely to be receptive.
- Whether we can get equivalent results in a shorter time scale by purchase outside.
- The extent of the opportunity that can be created.
- Where the best technology is available.

By using the resources of the Britax Automotive Component Division as a whole we have made innovations based upon single companies, transferred technology internally, acquired technology from external sources and also developed technology with our suppliers and Japanese associates.

Q11 *In the light of ACOSTS report "Defence R&D—a National Resource" and the Government's response, is there a satisfactory relationship between defence and civil sectors?*
My subjective comments suggest that the ACOSTS report reflects the difficulties of the defence/civil sector relationship as I would understand them.

I feel that opportunities for technology transfer do exist, and it would appear to me inconceivable that substantial technology transfer should not be achieved.

B. THE GROWING INTERNATIONAL BASIS OF THE VEHICLE INDUSTRY AND ITS EFFECT ON NATIONAL INNOVATION

The world automotive industry is changing rapidly, with ever-increasing co-operation taking place between vehicle manufacturers, and with major multinationals producing "world vehicle" programmes.

Joint ventures and shared vehicle programmes are also developing rapidly between manufacturers. The scale of the co-operative ventures undertaken by their customers, has created the need for suppliers to co-operate in order to provide an engineering resource to match those of the multinational customer and an ability to supply the vehicle manufacturing plant wherever located.

As a result of the requirements to seek a partner(s) to support world car programmes, technology transfer will inevitably take place between international competitors. Whilst Intellectual Property rights offer protection, much innovation concerns know-how, and the resulting rate of technology and know-how transfer overseas is a factor which could impact upon national initiatives on innovation.

C. MANAGEMENT FOR INNOVATION: A NEW INITIATIVE

This outline proposal suggests that whilst many Government initiatives have concentrated on the physical aspect of innovation, and with providing indirect incentives and support for industrial innovation, little has been done to examine the problems of the management of effective innovation within UK companies.

It suggests that examining cases of successful and unsuccessful innovation provides conflicting evidence of the factors which contribute to successful innovation in small/medium sized companies.

It asserts that successful innovation in manufacturing industry requires:

- High levels in competence and confidence in the management of innovation.
- A methodology for the management of change which can be used and developed, and which can be taught.
- Impsroved methods of personnel selection which will identify innovative individuals.

An outline programme for a Management for Innovation initiative is included.

It is believed that if UK industry could be more proficient in identifying the innovators, managing the innovation process, and introduce effective training for innovation, we would be providing the basis of improvement in innovation rates which would be of long-term benefit to UK industry.

RESPONSES TO SPECIFIC QUESTIONS RAISED

Q1 *What are the effects of company attitudes and structures (including personnel policies and investment decisions)?*

The Influence of Company Attitudes

The question would suggest that company attitudes and structures are a major influence on innovation, and can both promote and inhibit innovation.

I believe that it is far less subjective than the word attitude usually implies. The process of innovation and the promotion of spontaneous innovation within an organisation requires far greater positive input than a mere attitude.

Innovation is a Risk Business

By its nature the pursuit of innovation, on a grand scale by entering a new market or introducing a completely new product line, or in a minor alteration to an existing process is a high-risk occupation not to be lightly undertaken.

These risks are not only the major external and commercial or professional risks of a new idea, concept, process or product, where money and time has been spent in pursuit of the innovation, but also an internal risk to those unassociated with the process of development and research which has led to the decision to proceed.

The board or senior management have both the privilege and responsibility to initiate major changes in the companies' activities, and are held accountable for their actions. Their acceptance of these risks of innovation, or the risks as they perceive them, will depend upon their view of the balance between risk and opportunity.

The board's decision to change however will have implications, directly or indirectly, on the whole company. The salesman whose earnings can be affected or who has not been trained to handle a more technically demanding product; the operator who sees the product he works on being obsolete; the foreman who sees his department shrinking in importance, all are threatened and see a direct personal level of risk in innovation.

It is against this scenario of change in depth that the management decision to innovate then asks for extra effort from its staff to undertake the stress and upheaval of introducing and making effective the changes planned.

Similarly, since management is duty bound to improve day-by-day, year-on-year, apart from major company change or innovation, a company must demand that continuous improvement at the operating level is obtained.

Innovation in an industrial environment involves the management of risk, of the creation of confidence to move away from the time-honoured and well known, and the creation of an organisation-wide environment of shared risks.

Management for Innovation

To be successful, and to create an environment where innovation is not just tolerated as a necessary evil but welcomed and promoted at all levels requires specific conscious management organisation, style and conduct which are consistently applied.

Six areas need to be specifically addressed:

- The creation of a clear co-ordinated plan and direction for each activity of the company, and the ability to change rapidly if circumstances alter.
- The development of realistic delegation and organisation not only in respect of responsibility for events but also in the opportunity to change and improve the methods and effectiveness of the company's basic capabilities.

- The creation of an expectancy that change, some change—however small—will take place at all levels of the company to make tomorrow just a little better than today.
- The sharing of risk—all change carries risk, the risk of an innovation undertaken in this environment should be shared by all levels of the company.
- A system which publicly recognises successful change and uses failures as a means of learning by all.
- Continuous training in key skills of analysis, problem solving and fault finding to raise confidence in all employees to identify and explain to others the need to change and to be competent to challenge existing methods with the specialists responsible.

These management steps must support those of providing a basis for competitive innovation:

- Well developed market intelligence to identify trends, gaps in the market place to be exploited, and competitive threats that must be countered.
- The creation of an adequate basis of technical skills, or access to sources of those skills to identify and develop, or acquire the necessary technology for progressive change.

Management initiative

I have indicated above some key elements in creating an organisational willingness to change. It also requires that management has itself accepted its primary role of not merely preserving the status quo, but of positively directing to achieve change on a co-ordinated basis throughout the company.

Company Structures

Whilst it seems clear that the development of over-rigid organisation structures can inhibit innovation, this does not seem to be universally true, with many large organisations using relatively rigid structures and operating procedures being successful innovators.

In small- and medium-sized companies, this rigidity of structures and procedures is not so prevalent, and there are significant gains in flexibility that occur not only in respect of innovation but in all areas of activity.

Within the Britax Automotive Component Division we have developed forms of organisation which have benefitted our overall performance.

The principles we have followed are:

- To subdivide manufacturing units not by process but by product. This has led to an organisation whose unit size and structure is related to product needs.
- To pass responsibility down to manager/supervisory level of these manufacturing units, and to reduce the size and power of company service departments (Material & Production Control for example).
- Coupled with this has been the increasing dedication of plant and equipment to specific product lines, leading to sharply reducing the interdependence of unrelated elements of the manufacturing process and product range.
- These moves have been supported by significant training in what were previously often regarded as specialist skills (problem analysis, quality control procedures, manufacturing planning, etc., etc.) which has increased problem solving capability at operator level.
- Increased the level of forward planning resource available through better problem solving at operator level.
- Used decentralised DP systems to make modern computer technology available at the lowest level possible.

In the grand scale of innovation these effects have been minimal, but in the creation of an environment of sustainable and continuous spontaneous innovation and tolerance to change in the company, they clearly have had a significant positive effect.

Investment Decisions

Investment levels have increased, but whether this is solely a feature of revised structures or increasing technical requirements is not entirely clear.

In general terms, the gains that have been made by a revision of previously conventional operating practices and structures have enabled the higher levels of investment to meet the financial criteria required.

The size of contracts in the Automotive Industry now that vehicle manufacturers have sought to restrict the number of suppliers of a component, has also raised investment levels but, over a much larger contract volume.

I feel that the basis of investment decisions are not a major constraint against innovation in our type of business as a component supplier to the world's Automotive Industry.

SUMMARY

Lack of innovation in today's situation as a permanent state in a company can be explained not only with reference to the existence or lack of the right attitude, but also to more fundamental questions in relation to the management of the innovation process.

If the "attitudes" referred to in the question are seen as being a conceptual and abstract "willingness to change", then my answer to the question "what are the effects of company attitudes and structures" is, almost certainly, that they have almost no positive effect, and may be destructive.

If the word "attitudes" embraces a total management approach they are vital to creating a willingness to innovate.

The desire to generate a culture of spontaneous innovation within a company must take into account and consciously seek to change all aspects of the company. The structures which management impose are a major factor which can stultify progress or sponsor willingly accepted change.

Q2 *How active are UK companies in seeking out external technology, especially from overseas? How well do they adapt and apply it?*

Knowledge of Internationally Competitive Technology

I have indicated in my notes on the Britax Automotive Component companies (Appendix A) that we make conscious efforts to improve our knowledge of the state of technology in our industry world-wide.

Our geographical dispersion, in UK, Australia, France and the customer base we serve (German, French, Spanish, UK, Australian and the USA) and our business with Japanese implants provides us with a base of contacts which we use to maintain close touch with the latest trends.

In addition, and as a deliberate policy, we have sought out comparable companies in Europe and Japan with whom we have established close links. This has represented a significant investment in both management time and expense. Interchange of visits, extended training of our staff in Japan, exchange of information in process development have all taken place as a result of this initiative, and equipment provided and direct technical assistance given.

Management Technology

Just as important has been the benefits we have gained through not only access to Japanese management techniques through our contacts in Japan, but also our exposure to Japanese management practices in the UK at Nissan and in conjunction with Honda UK.

We have consciously set out to meet all the customer requirements and to adopt and adapt suitable good practices for use internally as a matter of course.

Customer Influences

In many cases, multinational car manufacturers require more than one source for a specific component range, e.g., rear lamps. As a part of the overall contract, one supplier will be given responsibility for development, the "lead" supplier, with the other(s) being responsible for production supplies from the agreed design.

This has had three effects:

- It has been necessary for our technical services, specifically CAD, to have the capability to deal with all major customers and key competitors.
- It results in informal links being established between suppliers which does increase the chance of technical exchange (whilst the process does encourage the exchange of ideas, the transmission of ideas can sometimes be conducted in less than a frank and open manner).
- On the other hand, multinationals accepting a design innovation for a new product will require that the "inventing" company grants a free licence to the second supplier for the purposes of that model contract as a consideration for obtaining the major share of the business.

Other factors

Similarly, we maintain close contacts with our material suppliers in Europe, on a regular basis through review meetings and utilising their own technical support services.

Technical journals, shows and exhibitions, etc., all need to be continually reviewed, and improvements in making information available or accessible for smaller companies may well be worth examination.

SUMMARY

The Automotive Division is making strenuous efforts to ensure that we are up-to-date with available technology.

Our customer and supplier base provides a good source of information on available technology and we systematically research suitable new technology as it becomes available.

Our contacts with comparable companies overseas have provided us with a source of technology as has our experience with Japanese management methods.

We would not claim perfection, but make strenuous efforts to ensure we are aware of available technology and pursue its application.

Q3 *What are the respective roles of product development and production engineering in technological innovation?*

There has been an accelerating change in the relationship between Product Development and Production Engineering in technological innovation.

The traditional relationship of Product Development resulting in a design, which Manufacturing via Production Engineering must make, is fast becoming irrelevant to today's industrial development.

There are reasons why this "relay-race" approach with the "baton" of a new product being passed sequentially through Development, Design, Manufacturing Engineering, and Production, is changing to reflect influences from outside as well as within the manufacturing company. The main influences would seem to be:

- Increasing market-led innovation and shorter product life.
- Increasing technical innovation and development in new products.
- Higher expectations of quality and performance and insistence on right first-time manufacture.
- Increasing complexity and cost of modern manufacturing methods particularly in high volume consumer products.
- New concepts in manufacturing processes and technology affording greater flexibility are removing many of the constraints on low volume manufacture.

Increasing Market Led Innovation

The speed of innovation demanded by the marketplace has dramatically increased. It is relatively unclear whether this is as a result of market pressure which demands innovation for its own sake, or whether world wide competition has generated the need to constantly seek to update product to maintain a competitive edge (an extreme form of planned obsolescence).

The effects of this can best be seen by examining a major cash-and-carry photographic dealer. A camera manufacturer's product range will change, and provide new products at least once a year, updating of existing products at least as frequently, with marketing changes to packaging, etc., occurring continuously.

The effect on the innovatory process in this industry has resulted in:

- The need to regenerate the product range on a time-scale of months not years.
- The need for development to be a continuous progression, taking place simultaneously on:
    - Updating existing product.
    - Bringing into production the next new product.
    - Tooling the following product.
    - Researching the next generation of product.

Simultaneous Engineering

Against this scenario, there can be no pause between proving a product as suitable for sale and that product being available in the market.

As a result what is now known as Simultaneous Engineering has become the norm, under which product design and development, facility design and development, tool design and development take place simultaneously as against the sequential relay race mentioned above.

Increasing Technical Innovation and Development in New Products

The desirability of short product development cycles has become a necessity to enable the pace of market-led innovation demanded to stay competitive.

The same pressures apply to the technically-led innovation, where new designs using new technology need to have simultaneous development of processes, equipment and tooling.

Higher Expectations of Quality and Reliability

Whatever its causes, the ever-rising expectations of Quality and Reliability created during the late 1970's and 1980's have put a premium on a radical change in attitudes to manufacturing system design. Trial and error have been replaced by a systematic adoption of techniques aimed at ensuring that the product will perform before production commences in safety and reliability terms, under conditions normal during its lifetime, and to cater for expected misuse.

In order that these requirements are met, techniques (FMEA for example) are used and the critical review of a proposed product now involves not only the design process but the total manufacturing process, the systems used being designed to ensure consistency, defect elimination, product safety, and reliability of the system as a whole.

Increasing Technical Complexity

In high volume product, increasing technical complexity is only acceptable if the manufacturing methods are capable of accepting the more complex products, whilst maintaining reliability.

The more frenetic the rate of technical change the more critical do the production engineering aspects of manufacture become.

This is tending to blur the traditional Product Development/Production Engineering boundaries, both in time terms within the overall programme time frame, but also in the necessity for simultaneous engineering at all levels.

New Manufacturing Concepts—low volume products

In parallel to the trends in high volume manufacture, technology is providing methods of manufacture which are more flexible, more capable and more effective in manufacturing small batches (from one off to, say, 500).

Computer-controlled machines, machining centres capable of many operations in random order, laser and other techniques of cutting and forming materials all have changed the economics of product innovation. Setting up has been virtually eliminated, alterations can be made in a computer programme and instantly introduced.

The techniques themselves place limitations on product design which must be known if the design is to take advantage of the new technology.

These factors are all creating pressure for an integrated engineering approach, where Production Engineering is a full "real time" partner with the Design and Development Engineer (as opposed to previous experience when the Production Engineer was often left holding the parcel when the music stopped).

SUMMARY

The increasing rate of change and reduced development time cycles demanded by our customers has fundamentally changed the relationships between R&D and Product Design, and the associated Manufacturing process development.

The need to simultaneously engineer both the product and the manufacturing process is increasing the importance of high quality Manufacturing Engineering skills as an integral part of the Product R&D in design process.

The creation of more adequate resources in the area of Manufacturing Engineering is an urgent need, as is the development of improved methods of management of innovation programmes.

Q4 *How effective are the activities of government departments in promoting and supporting innovation?*
If one observes the strict definition of innovation which has been adopted for this paper (P3), then one could conclude that Government can only indirectly promote innovation.

The commercial exploitation of new ideas can only take place where a new product or process can be profitably manufactured and sold.

Assessing the Risk of Innovation

The identification or creation of a market need, the evaluation of the commercial potential of innovation to meet that need, and the consideration and identification of the acceptable level of risk can only be done by the enterprise. Every company or organisation will have to take into account in reaching a decision to proceed factors such as:

- Its present position in the market.
- The competitive threat/opportunity and its effect on timing of a successful new product.
- The available potential solutions.

- Its resource levels.
- The evaluation of the relative risks of various responses to the perceived threat or opportunity.

Effectiveness of Government Action

Government can have no effective direct input into a company's decision making, nor can it affect perceptions of what would represent success and what level of risk is acceptable to the company.

These would seem to be the reasons that Government action to promote and support innovation has taken the form of:

- Offering some insurance against the risk of innovation by awarding financial grants to encourage higher-risk projects to be considered viable.
- Examining the form of other indirect financial incentives with the same objective (fiscal measures/accounting treatment).
- Attempting to create an environment of "willingness to change" to offset the perception of a national propensity to be good at creation of ideas, but poor at exploiting them by establishing programmes or initiatives to provide a form of catalyst for innovation.
- Indirectly attempting to create a willingness or create mechanisms to bring research bodies and Higher Education Institutes and industry together.

In answering the question "how effective" have these Government's actions to promote innovation been, I can only answer on the basis of our direct experience.

We have taken advantage of various schemes offered by Government:

- an early automation project—grant awarded.
- Various consultancy exercises where a portion of the costs have been paid by Government.
- We are currently a subscribing member of the Eureka project (DTI Infact project), a consortium of European companies and Institutions aimed at developing flexible small part assembly methods using transputer driven automation.

What has inhibited Britax from using the Government Initiatives more effectively?

Our joint experience has been that there are three major factors:

- The insistence that assistance will only be provided if we can show that without assistance we would not proceed.
  We are in a business where decisions on contracts have to be made to very tight time scales. Not infrequently we have to decide to take a contract before we know precisely how we propose to meet the requirement. (Q.9)
- The time scales required for submission and grant approval.
  The bureaucracy demands a level of detail and diversion of resources and time not always available.
- The proliferation of schemes has presented a maze through which one must pass.

It could be reasonably argued that we have not systematically tackled innovation as a fundamental need but only as required by our immediate contracts. We are not untypical of average medium-sized companies, and our limited use of what Government must feel was an adequate range of potential assistance must be even more of a limitation for the myriad of small companies when ± 80 per cent of total employment is in companies of less than 20 people.

CAD—a case in point

Of all the innovations that have occurred in the last 10 years, that which has created a virtual revolution in Design/Manufacturing and R&D has been the availability of effective Computer Aided Design. Further developments are going to widen the already vast gap between the "haves" and the "have-nots". At present widely used in large- and medium-sized companies it is equally a vital necessity that its use is widened across the smaller companies if they are to survive.

The Automotive Component Division recognised that investment was essential, and have so far, as a division, has made a capital investment of over £750,000 on 3-dimensional CAD.

We have in addition invested significant amounts on ensuring compatibility with CAD systems in all our major customers, networking our company based installations, and developed effective data management systems.

We have the proven capability of receiving directly CAD data of body shapes taken directly from the clay model at our customers and producing finished product off-tools with no physical representation (by way of models, hand made samples, drawings for example) existing between the clay model and the finished product. We were the first to produce an optically correct lamp for Ford using only CAD/CAM, and were asked to present this to Ford USA as an example to be emulated.

We have continued to integrate the CAD design capability into Computer Aided Manufacture together with simulation to prove the design entirely on computer models.

The purpose of highlighting this is not self-congratulatory, but merely to emphasise that had the companies which comprise the Britax Automotive Division of BSG been independent we would have been unable to justify this level of expenditure of money and resources in any credible terms of economic payback.

The decision to invest was an act of faith. It is true that our customers were applying pressure for companies to adopt CAD, but in terms of justifying the project the benefits were not quantifiable in economic terms.

We did not feel that we had the option of not investing nor any doubts of the value of that investment and are convinced of the benefits we have gained technically and commercially.

The potential "Have-nots"—the Small Companies

If we, as a group, could provide the risk capital, where individual companies of the Group could not on a stand alone basis, what chance for the majority of small companies? How are the small toolmakers and specialised manufacturers to take on the new technology?

Even if the initial investment is made possible, the rate of development is such that regeneration and "modernising" CAD facilities is already approaching a requirement to effectively re-invest the initial cost every 3-4 years.

A Continental Case

Availability of high quality tool making is a necessity as products become more complex and quality standards rise.

It is clear to us that this can only be competitively achieved using CAD/CAM (Computer Aided Manufacture) for tool design and tool making.

The availability of tool making facilities capable of meeting these requirements is not an inexhaustible resource, and new car programmes generate a load which has to be spread throughout Europe and even world wide.

We have identified a Spanish toolmaker who is a specialist in our technology, who employed some 40-50 toolmakers.

He has acquired the latest "state of the art" equipment, 50 per cent of the cost of which was provided by a government grant.

He is now able to compete on price, delivery and quality, and can give and receive data directly to his customers, and has over 100 toolmakers.

If small UK toolmakers are unable to follow the Spanish example quoted then we are going to see a systematic transfer of business, opportunity and technology to more favourably placed competitors overseas.

Effective Government Action

Whilst accepting that Government resources are not an inexhaustable resource, it would seem that special help may be necessary for small companies, specifically in the field of CAD.

SUMMARY

Whilst many initiatives have been supported by Government action, they have in our experience been of limited value.

Appreciating the need for control and the desire of Government to grant scarce resources on a priority basis, the bureaucratic process has been an inhibitory factor to the Automotive Component Division, and must have had an even greater effect on smaller companies.

Some special assistance in the field of CAD, which may not necessarily fall within the grant structures used so far, could be seen as an opportunity for providing essential assistance to small companies with the impending skill shortages forecast for the future.

Q5 "*What are the effects of City attitudes to investment in innovation*"?
I can only provide comments as an interested observer in response to this question, as I have had little direct exposure to the problem which has been the subject of much media comment.

Certainly I am aware that there is a perception of a fundamental change that has taken place over several years. It seems clear that, in today's circumstances, City expectations demand an ever shortening horizon. If this is true in fact, and not just as the press see it, then it will have an inhibitory effect on companies' preparedness to invest, and as innovation is a high risk activity it is most likely to be affected.

As a supplier to the motor industry our overall investment time table spans 2-3 years on a typical contract.

Investment Levels—a representative case

Whilst price competition is fierce, individual components have to be internationally competitive and unit prices for our smaller components are typically in the £5-15 range. A contract for 50 per cent of the volume for major car programme say, a Fiesta or Peugeot 205 mirror or rear lamp, will have a Sales Value of £10-30 per vehicle for Right and Left hand components.

A typical programme

The following demonstrates the key features of a typical programme for rear lamps on a high volume vehicle.

Typical Rear Lamp Programme—(all figures £million)

Total Sales 5 years Production + 10 years Spare Parts
— 1000 vehicles/day @ £30 per vehicle ± 44.0

TIMING

— Design starts	2 years before production
— Tooling completed	up to 12 months before production
— Delivery of parts	3-6 months before vehicle launch in market

EQUIPMENT

— Paid by supplier (typical cost)	1.25 – 1.4

TOOLING

— Normally paid by customer	.75 – 1.0
TOTAL PROGRAMME INVESTMENT	2.0 – 2.4

INVESTMENT LEVELS

At any one time a Britax company could have 4-6 programmes at various stages of development but not yet in production, with commitments and expenditure of up to £2.5 million on each programme held over the design and development period. In one company during 1988-89 we introduced 13 new products of all types in 12 months, and major European projects can involve more than one Britax company.

This places severe strains on capital resources and a major factor affecting short-term profitability since paybacks on such projects extend for 3-4 years. The resources committed will be exaggerated in times of rapid growth.

This demand on capital and its consequent effect on profits can inhibit R&D expenditure where this is written-off in the year of spend.

It also limits available funds for innovation, and with the City taking a short-term view can represent an inhibitory factor to a small/medium sized company.

SUMMARY

In the Automotive Industry, increasing vehicle production, with the number of individual vehicle designs being steadily reduced to achieve economies of scale, the pattern of investment by a component supplier is rapidly changing.

This combined with the rising cost of this up-to-date technology, which must be used to maintain an international competitive edge, together with more and more investment taking place much earlier in the Vehicle Development cycle than before, is increasing both the amount of investment and also increasing the gap between investment taking place and income being generated.

In financial terms, short-term company performance as reported in financial accounts, and upon which the City passes judgment, can be distorted by the successful acquisition of a major contract, where major capital expenditure must increasingly be made more than 12 months before product can be sold to recover the costs.

In periods of successful expansion this presents a drain on funds and affects short-term results of a company which in other terms would be felt to be highly successful.

It must represent a severe penalty on smaller companies whose breadth does not allow for the effect to be spread over a large range of products, units or markets.

Q6 "*What is the effect of the legislative and regulatory framework concerning for example labour costs, patent laws and tax concessions on R&D and purchase of know-how?*"

The cynic would argue that the regulatory framework, by this I refer to regulations concerning minimum product standards, e.g., exhaust emissions and fuel consumption legislation (USA), safety belt standards, unleaded fuel tax concessions, and product liability legislation are the most effective stimulus to innovation provided by Government, since unless it is law, companies will fail to invest in developing products compatible with consumer needs.

This could be argued to be true of the motor industry of the 60's and 70's but I do not feel that it has the same effect today, when world-wide competition has to be faced with an increasingly discerning and well-informed customer.

On the other hand, regulatory standards and framework can be operated as a hidden form of protectionism (ref: France and Japanese Video recorders).

More critically, in the motor industry we are faced with not only a multiplicity of regulations on a country by country basis, but also, and more obscurely, a failure to comprehensively develop consistent international or European standards of testing and approval.

The standards procedures as currently developed describe performance standards, but in many cases do not prescribe detailed test procedures or standards of acceptance. These elements are frequently left to individual test stations.

Regulation as a blocking mechanism to Innovation

There is anecdotal and superficial evidence that the Regulatory Mechanisms can be actively used to block innovation.

In many cases, Regulatory Bodies rely on some form of Policy or Steering Committee drawn from representative interested manufacturers.

Whilst intended to ensure that by maintaining contact with industrial developments, regulation can be regularly updated, the prominence of large manufacturers on these "Steering Committees" can result in selective progress being made in updating regulations.

Coupled with individual company preferences and bias, customer-specific quality and design procedures and attitudes and a tendency still to sustain hidden nationalistic preferences by using the regulations and procedures to exclude unwelcome competition, they present a situation which can favour emulating a product already approved rather than take the risk of breaking new technical ground.

Labour Costs

Labour costs are unlikely to affect decisions on R&D and purchase of know-how, but the reduction of costs would be a prime objective of any development.

Patent Laws

These are perceived as a fixed element of the environment we work in, and will not significantly affect our willingness to do R&D or purchase know-how.

Tax Concessions

As far as Tax concessions on R&D and purchase of know-how, I have no first-hand evidence that they have any effect of substance, but this may be a feature of the industry and product range we supply.

SUMMARY

Regulations have in the main provided the most powerful stimulus to ensure innovatory change, particularly in consumer-related areas.

The mechanisms are however open to pressure to block innovation by influencial Steering Committees.

Adoption of the single market which superimposes increasing centralised European regulatory mechanisms represents a potential growing restriction on innovation if operating methods and procedures fail to adapt to be consistent with the single European Market.

Q7 *How effective are the mechanisms for technology transfer from HEI (Higher Education Institutes) Research Councils and public laboratories?*

As a potential customer I regret that from first hand experience they are clearly not always effective. This is not to say simply that all the fault lies with the mechanisms. It can equally be true that company mechanisms and procedures are not effective.

Major Constraints for Medium-Sized Companies

There would seem to me to be major constraints on the effectiveness of external institutes and laboratories.

If, as I believe, innovation is a process of translation, of bringing together known technology in new combinations to provide a commercially viable product, there is an inherent difficulty of knowing where these individual elements of technology are being considered/researched.

It follows that in searching for several strands of knowledge to make up a base for innovation, to be effective knowing what work is being done, or even what broad categories of Research and Technology are being investigated in each institute, represents a minimum basis for establishing feasibility of further contact.

It has proven difficult to suggest how this data base can be made accessible.

A second constraint is the lack of industrial experience and knowledge which exists in many HEI and also the lack of product knowledge and isolation from the industrial environment.

Our material and component suppliers represent a faster and more effective route for accessing technology, particularly raw material suppliers. Major raw material suppliers are in touch with not only our segment of the market, but our customers and our equipment manufacturers, and are large enough to be involved in research either on their own account or in conjunction with HEI's in major research products.

HEI and Technology Transfer

The influence of HEI in respect of Technology Transfer may be proven to be successful and positive in relation to specific areas of industry but these would appear to be where major research projects or defence issues are concerned, or where companies are operating in high technology business.

From the point of view of a medium-sized company the view is less clear. Seldom is the level of innovation in medium-sized companies at a "Frontiers of Science" level.

The prime requirement is:

- To find a potential source of assistance.
- To identify the possible opportunities or routes to achieve a solution, having defined the problem.
- To jointly develop ideas to the stage of feasibility.

Lacking any easy reference as to what work is being carried out and equally importantly, by whom, in many cases HEI are seen as being largely irrelevant to the problem.

Far more rapid and precise responses are usually available using industry knowledge, component suppliers, sub-contractors and material suppliers.

This scenario is mirrored by my own experience when looking for assistance.

On the occasions where I have felt that a potential project would have mutual benefits to both an HEI and the company results have been extremely disappointing.

Responses from HEI have been very limited, ranging from NIL response to initial enthusiasm for a project being a short-lived phenomena. Even from an HEI which designates itself as "industry oriented", responses have failed to adhere to the commercial objectives set and timing constraints given, and the quality of the work did not reflect the early promise.

There would appear to be a multitude of problems:

- There are few aids to enable a company to identify where specific categories of expertise, interest or research capability exists into the specific problem.
- Internal communications in HEI appear of variable quality in analysing requests for assistance and project potential sufficiently well for it to be directed to the correct department, and sometimes even to produce any reply whatsoever.
- There appears to be no incentive to accept outline projects and where a project is accepted it rapidly can be passed down to too low a level of skill.
- Lacking an environment where regular amounts of work are done in the industrial scene, and the necessary resource scheduling developed for external projects to be effectively handled, the access to HEI is limited by the imagination, current interests and relative enthusiasms of individual members of HEI staff.

Where we have achieved some success, it has been through personal local contacts with members of staff not because of any systematic approach by an HEI to provide an effective service to industry.

Technology Transfer

None of the above refers to Technology Transfer directly, but if the initial contact mechanism is poorly defined within HEI, the first key step which would lead to projects offering serious attempts at Technology Transfer cannot be taken.

One possible explanation to this situation could be felt to lie in what is fundamentally an unrealistic expectation on the part of industry in what an HEI sees as its role (or more critically what a specific department adopts as its role).

Whatever the causes, the perception that HEI have little to offer hard-pressed industry can restrict projects for HEI/Industry co-operation.

Research Councils & Public Laboratories

Research Councils & Public Laboratories have not featured in our innovation programmes.

SUMMARY

Given the resources made available through HEI, it is disappointing to have to convey the opinions above. This view is not universal, and major industries (steel, coal, oil) have clearly developed some synergy between HEI and industry, but for the average medium sized company, HEI involvement is rarely considered, and still more rarely actively, effectively and consistently promoted by the HEI themselves as being available to small and medium sized enterprises.

Only in rare cases (the Accident Research Institute at Birmingham for example) has an HEI developed a significant enough presence for a long term Industry/HEI link to be established within my direct knowledge.

Q8 "*Does UK benefit sufficiently from EC support for innovation? How might it be improved?*"
I am not competent to pass a judgment on this aspect, having had no direct experience.

Q9 "*What are the effects of the varying relationships between companies and their suppliers?*"

Relationships between Britax and Car Manufacturers

As a supplier to the main line automotive manufacturers our customers' attitudes, personal preferences and design philosophies all play a major part on the innovatory route we follow.

The main aspects are:

- Customer expectations of its suppliers.
- Commercial aspects and international competition.
- Timing constraints.

Customers' Expectations of Suppliers

There has since the late 70's been a radical shift of emphasis, stimulated in the main by rising expectations of product quality and reliability and by exposure to Japanese management techniques.

These factors have affected the vehicle manufacturers' own in-house operations, have dramatically increased the technical work load placed on the car manufacturers' staff and also caused a major shift of engineering workload with the major workload taking effect in parallel with vehicle and component design. With the need to both accelerate the design cycle to meet increasing competition and reduce product life, the resulting concentration of work load and the emphasis on pre-planning has forced a major change in attitudes, strategy and practice in the manner in which the vehicle manufacturer establishes its supplier base.

The result, affecting all vehicle manufacturers, has been:

- To restrict the number of suppliers.
- To pass an increasing degree of design that had previously done in-house to this restricted supplier base.

This has forced a major programme of supplier quality assurance in the pre-planning process as a means of underwriting the risk of passing part of the design responsibility to external suppliers.

This change has resulted in a fundamental movement of emphasis from a situation where the contracts for supply of components were gained upon a competitive price for a design largely prescribed by the car manufacturer, to one where:

- Suppliers have to have proven technical capability in R&D.
- Suppliers must meet rigorous standards of design disciplines, product quality performance and rigorous manufacturing methods covering all aspects of quality control.
- Suppliers must demonstrate the ability to maintain competitive technology (to innovate).

Suppliers or would-be suppliers have not only to commit to conform to these requirements on new products, but in order to reach the status of a "Preferred Supplier" (or equivalent title) have to demonstrate that these standards of product quality, delivery performance and competitive pricing can be maintained on current products in production to sustain the confidence of a customer to place future contracts.

Commercial Aspects

The results of the need to meet these expectations, and the fact that these standards are uniformly applied (though individual preferences and political influences can still be detected from time to time) has made quality no longer a selling point—all preferred suppliers produce good quality, are reliable and competitive in price.

This then puts a premium on the supplier's ability to innovate in all aspects of his business to create any differential which will encourage the customer to place contracts.

Notwithstanding the desire to restrict suppliers, multinational vehicle manufacturers have been subject to pressures to:

- Limit the risk on a component by having a limited number of supply sources for that component (seldom more than three for a multinational programme).
- Political pressure to source supplies in the country in which they assemble (as a *quid pro quo* for receiving financial or other assistance—commitments to local content).
- Limit engineering control problems by appointing a single supplier as a development source with the responsibility to furnish the appropriate technology to the other supplier(s) involved.

The need to innovate is still paramount, but the suppliers involved in this type of arrangement will be unable to exercise absolute control or to restrict access to the technology, and notwithstanding any patent rights will be expected to grant a free licence to a competitor who is also a supply source for that vehicle or project.

Timing Constraints

The acceleration in the Development phase of a new vehicle demanded by the need to match rising rates of innovation by competitors, and the movement forward in development cycle of the major phase of pre-planning and design has also begun to place constraints on the introduction of innovation.

Faced with the combined stresses of the reduction in total vehicle development time and the need to raise technical standards, the increased load of pre-planning raises dramatically the risks inherent in the vehicle development programme. Not only are major elements entrusted to external sources, where promised product performance has to be taken to a degree on trust, but the risks have to be taken very early. Once a potential "lead" supplier has been selected, any subsequent change is likely to have serious ricochet effects on the total programme.

It is not an unnatural human response for a hard-pressed vehicle design engineer to feel that taking an additional risk, on a supplier's belief that he can deliver new technology to a tight schedule, is one risk too many.

SUMMARY

The change of emphasis under which many vehicle components are designed not by the vehicle manufacturer but by a nominated and proven component supplier has, and will have, a significant effect on innovation in the industry.

Smaller companies to continue to exist must prove total technical competence in the selected product range. They must have the capability to innovate and be innovative not only in product design terms but across the whole manufacturing technology.

With Multinational Customers, patents can be of limited value, since a precondition of a major order from a multinational customer will be the provision of technology to a competitive supplier of part of the same contract.

The tendency is growing, therefore, to demand increasing technical resource from suppliers, and to further increase the total investment in development and innovation, placing a further strain on company cash-flow with greater front end loading of expenditure and increasing the time gap between investment and cost recovery.

Q10 "*What factors influence decisions to invest in innovation in the UK or overseas*"
As explained in my notes on the Britax Automotive Component Division, we operate in the UK, Europe, Australasia and the USA, and our customer base contains elements of all major vehicle manufacturing regions.

We do not have centralised R&D, and individual companies pursue the needs of their individual markets. Innovation resulting from this strategy is made available throughout the Division.

Our contacts in these territories ensures that we have knowledge to a degree of technological trends in our customers, suppliers and competitors as they affect our product range.

The factors which affect our decision on sourcing innovation and where investment in innovation is made are comparatively simple:

— Where the need exists—or business opportunity can be perceived.
— Where our customers are likely to be receptive and provide support in accepting a new idea.
— Whether we can get an equivalent result in a shorter timescale internally or whether we go outside.
— The extent of the opportunity that can be created whether it is a project with universal application or limited in the medium-term to a single customer or supplier.
— Where the best technology is available.

Under these general criteria we have innovated:

— On a single company basis.
— Taken elements of a single company project and developed it for other markets/customers.
— Acquired technology from external sources.
— Developed technology with our suppliers.
— Acquired and provided technology to and from Japanese associates.

The question "UK and overseas" does not form a conscious part of our decision making, which is conducted on the basis of a professional and technical assessment of the individual project.

Q11 *In the light of ACOSTS's report "Defence R&D a national resource" and the government's response, is there a satisfactory relationship between defence and civil sectors?*
I have little direct experience which qualifies me to offer a judgment on the relationship between defence and civil sectors.

The only comments I can make are subjective, and represent a personal point of view, but several topics discussed in the ACOST report appear to me to be relevant.

Factors inhibiting technology transfer between defence and civil sectors

— Defence secrecy rquirements.
— High defence specific technical requirements over and beyond those required in normal industrial use.
— Defence contract structures provide few mechanisms or identify the responsibility/need for technology transfer.

The limited application of defence technologies

There would appear to be an assumption that innovation and technology transfer between civil and defence areas is unlikely for the reasons given above.

This can be felt to be true if innovation and technology consists of objects and products rather than processes, ideas and concepts.

If innovation is, in fact, an exercise in translation, of bringing together in a new commercially viable product existing elements of technology, then it seems to me inconceivable that defence technology has not any element applicable to civil industrial applications.

For example: missile guidance and control systems require, in my imagination, fast and accurate response in a hostile environment. These same conditions apply to much industrial automation. The industrial scene has no use for missiles, but the elements of missile technology—miniaturisation, special materials, fail safe mechanisms—all have relevance.

Development Contracts

No mention in the papers I have read, discusses or mentions the Development Contract as a feature of Defence R&D contracts.

In industry, the use of a Development Contract is well established, and includes in its features, not only the technical requirements to be met, prototypes, etc., but defines the commercial relationships in some detail:

- The contractor undertakes to supply a feasible design, or range of designs to meet a specification.
- The contract can include prototype supply and proving.
- Ownership of Intellectual Property Rights belongs to the paying client, unless specified otherwise in the Contract.
- Arrangements for exploitation of any innovative elements of the design are considered and specified in the Contract.

Major Defence Contracts clearly do not represent such a simplistic view, but, as an outside observer, it would appear possible that Development Contracts could be used in Defence contracts, with the intellectual rights being jointly owned by HM Government and the contractor.

This might present a scenario where Government could ensure that technology transfer does take place, as I believe NRDC used to oversee.

Clearly this is a general observation, and the problems have regularly been reviewed by previous Committees.

It would require:

- A rigorous separation of innovations into "Defence critical" areas not to be made available to the civil sector.
- Some mechanisms for making information available as to what innovation/technologies are open to the civil sector.
- The development of suitable commercial arrangements with Defence contractors to provide an incentive to set up the complex and expensive resources to manage the resulting situation.

THE GROWING MULTINATIONAL BASIS OF THE VEHICLE INDUSTRY AND ITS EFFECTS ON INNOVATION

There is one additional factor which I believe to be fundamental to any consideration today, of Industrial Innovation, and which I have found to be omitted from both the Select Committee Questions presented for a response, and also in such other publications on innovation that I have examined, and that is the effect of the growing internationalisation of Industry, particularly but not exclusively in the vehicle manufacturing industry.

The changing Motor Industry scene—a Worldwide industry

Examination of the industrial structure of the vehicle industry in 1990 reveals that, over the last 10 years or so, there has been an accelerating growth of co-operation, amalgamation and joint ventures formed on a world wide basis.

It is no longer considered essential that a vehicle manufacturer only produces vehicles in his own wholly-owned manufacturing facilities, nor that all the major components, engines, transmissions and suspensions (for example), are manufactured by a vehicle manufacturer for his own products.

Joint ventures, between vehicle manufacturers and component manufacturers, shared vehicle development programmes, shared vehicle marketing in selected territories, all form part of today's vehicle industry.

In parallel with these changes in vehicle manufacturing, the automotive supply industry is being forced to adopt a similar strategy and, to maintain its position, suppliers are having to emulate the car companies' strategies; to be successful, suppliers must be able to support world wide vehicle manufacture, with appropriate local component supply facilities to support car manufacturing locations.

The fear of over-capacity and the financial burden on a single supplier of sustaining growth by the traditional pattern of setting-up new overseas operations, or making acquisitions to provide local supply on a world wide basis has led to formal and informal arrangements being made on an increasing scale with companies overseas.

The effects on innovation

These trends have had a major effect on both the commercial aspects of what were traditionally felt to be "export" markets, and also the speed, pace and the sources of innovation.

The multinational vehicle companies must maintain their pressure to reduce the scope of their supplier base, and are increasingly looking for limiting the design co-ordination problems of multinational vehicle programmes by insisting that suppliers link together for a single "world car" model to provide a common engineering solution applicable to component suppliers in whatever country the vehicle will be assembled.

As discussed elsewhere in the Britax response, the traditional licencing and export of products has been partly overtaken by a situation where component supply companies are joining forces to secure the contract to supply, and accepting that previously jealously guarded technology will be available to their partners, previously competitors.

Effects on Government Initiatives in regard to innovation

The international "melting pot" that today's vehicle industry has become will have equally fundamental effects on national governments' attitudes and policies to supporting innovation. The extent to which this can change previous perceptions can be illustrated by the following hypothetical case in the automotive industry:

> *1960's pattern*
>
> If a government wished to promote electronic innovation in the vehicle industry in the UK, then it could consider an initiative to support a Research and Development programme to be carried out by UK HEI and industry.
>
> The results would be available to UK companies, who would benefit in contracts with UK vehicle manufacturers.
>
> *1990's pattern*
>
> If an identical initiative took place today, the results of the R&D if developed by a component supplier, and elements of the technology, would be required to be made available to others by a multinational customer, and could indirectly be transferred to component manufacturers in Europe, the USA, Australia and via associated companies to Japan.
>
> It remains true that Intellectual Property rights offer protection and should result in licencing royalties being returned to the UK, but much technology and know-how not necessarily patentable, and notwithstanding this, effective technology transfer will take place outside the UK and to the benefit of other nations' industry.

Conclusions

It could be concluded that with the growth of a multinational vehicle industry, and the ensuing need for co-operation amongst its suppliers worldwide, innovation in this industry will be increasingly difficult to limit on a national basis, and increasing innovation and technology transfer will take place in the process of obtaining contracts for world car programmes.

MANAGEMENT FOR INNOVATION

Since receiving the request from the Select Committee, I have addressed not only the questions posed directly, but I have reviewed my experience, both in main-line vehicle construction, and in automotive component design and manufacture.

Background

I have developed an increasingly strong opinion that Government and institutional concern with innovation and technology has polarised around the physical aspects of innovation—money, resources, technology transfer, HEI's research institutes, etc.

There would seem to be a view of innovation in UK industry that can be summarised as:

- Britain has a reputation for research and invention which compares well with the rest of the world.
- British Industry has a poor reputation of exploiting the results of this research, and too often other nations have proven more successful in developing British originated ideas than British Industry itself.
- Therefore there is something wrong either:
    - With British Industry
      or
    - with the relationships between research and exploitation.

Government response to this perception, much simplified above, has been to examine the problems in terms of mechanisms:

- Direct funding of research.
- Organisations and mechanisms to bring HEI and industry together—Research Councils.
- Mechanisms to offer financial assistance to reduce the financial risks of innovation to companies.
- Setting up organisations specifically to encourage technology transfer—BTG.

In spite of all that has been attempted over the years the dissatisfaction has persisted.

The initiatives taken by Government have in general been taken from this high level viewpoint, and appear to have relatively ignored the actual process of innovation *within companies.*

Reflections on Personal Experience

During this industrial experience there have been periods of intense and successful innovation within organisations, standing like islands in a sea of comparative stable "status quo" management.

In retrospect, the general conclusion I draw from this experience is that much of the successful periods of innovation have arisen not from any consistently acquired skill, but by a series of coincidental accidents.

In addressing the questions of the Select Committee this now seems an unsatisfactory conclusion, since it provides no basis for deliberate action to make successful change happen.

I find myself increasingly dissatisfied with the seemingly widespread assumption that the propensity to innovate or the lack of innovation in industry as a whole is in some way a process that can be influenced significantly by providing external stimulus. Such literature that I have examined appears to concentrate on what can be done from outside to "make them innovate", or what help can government give to encourage innovation.

The use of the phrase "pursuit of innovation in manufacturing industry" itself suggests that innovation is an object to be pursued as a fox by the fox hunt.

My own experience is full of contradictory evidence:

- How can two companies, of like resources and in similar industries, drawing their skills from the same population, have such differing rates of effective innovation?
- Why do so many development projects fail so miserably to meet timing and commercial objectives?
- What causes one company to be continually in a state of change whilst others protest their excellence all the way to the Receiver's Office?
- Successful innovation does not necessarily rely on high cost research, or large company size. Both large and small companies are successful innovators, some visibly more so than others. What creates successful centres of innovation?

These questions, and many others, can be found unanswered in, I suspect, the majority of companies.

It is my opinion that the answers to these questions cannot be found solely in the mechanisms existing betwen institutions, but also must be sought in examining the human aspects of change and its successful management.

Management Initiative—A vital precondition

What does seem to me quite clear is that within any organisation, no matter what size or type of organisation is considered, the INITIATIVES FOR INNOVATION CAN ONLY BE GENERATED INTERNALLY. No amount of exhortation or incentives can generate a willingness to innovate in an organisation, if the organisation does not perceive a need to change, or is unwilling to accept the level of risk involved.

The single most important factor in creating innovative change in industry is a clear recognition of the absolute need to change.

The power and responsibility to convert the ever-present dissatisfaction with the current status into a directed drive to innovate can only lie with the Chief Executive of the organisation.

Aspects of Industrial Innovation

The following aspects of innovation seem to precondition attitudes and willingness to enter upon a programme of innovation.

Confidence

- It is a risk business, and the willingness to endure a series of self-imposed risks is not a universal human characteristic.

  Risks are not universally perceived as equivalent by differing individuals. What is a large risk to one person is a detail to another.

  The point in the organisation at which a risk is taken changes dramatically the perception of the risk. To a proprietor of a small company the risk is personal—"the buck stops here"—and the individual will accept risks knowing that he not only has the power to say "go" but also to abort the project if the risk exceeds his tolerance levels.

  To an employee, whether MD of a subsidiary company or an executive in a large company, the perceived risk is measured by the individual's confidence in his understanding of the organisation's reactions to risk. If the organisation's reactions are unclear then risks tend to be systematically declined.

Confidence is a prime requirement to overcome the fear of failure, and without the ability to show how success can be achieved the risk of failure will threaten the desire to change.

Competence

- Indulging in innovation, even if the organisation's risk evaluation procedures are clearly defined, will inevitably result at some stage in challenging perceived wisdom and the internal experts who are the guardians of that wisdom.

  If the individual "sponsoring" the innovation lacks the competence to challenge the experts or more senior staff, or the training and skill to enable him to manage the ensuing conflict, the opportunity will be allowed to fade away and ultimately to die from simple neglect.

Methodology

- The major objectives of many established industrial organisations even when professing a need to innovate is to manage the maintenance of the ongoing business, to design the replacement product, to produce the current product, to control, to identify errors/changes and to adapt to minimise the current risks.

  It follows that as companies pass from the set-up and expansion phase of their existence into an "established" status, the average management organisation begins itself to inhibit change, by continuing to prescribe the "approved reaction" to change.

  A human analogy is appropriate: the body has two control systems: the reflex and the logical or executive. We do not have to stop breathing to eat. The reflexes provide the basic controls to maintain stability, leaving the executive system free to design, innovate and change.

  Innovation needs Management to provide both a reflex type organisation to maintain the present steady state, whilst a separate executive system is dedicated to initiate change.

  Many industrial organisations give the appearance of having allowed the reflex to determine all actions, with no methodology to enable creative activity to take place on a broad front, i.e., outside the strict organisational framework.

  Without agreed methodology for initiating change the *status quo* becomes dominant.

Identifying the Innovators

Finally, it seems evident that the propensity to innovate is not uniformly distributed. The evidence suggests that there are individual attributes, arising from individual background, education or environmental aspects, that predispose individuals to be leaders in innovation.

Innovation is not the perogative of the skilled specialist, but must be encouraged at all levels. The innovatory ethos, the pressure to change, must involve not only specialist engineers, but all employees in the everyday operation of the business.

The modification of a tool or workplace layout, revised machine settings, minor changes to fixtures, adoption of new computer systems, all represent innovation and if sufficiently encouraged will generate a through-company expectation of innovation which will do much to eliminate the resistance, so often criticised, to new technical innovation.

Conclusions

In summary: the Revolutionaries in 1917 said, effectively—"if you organise 2 per cent of the population you've got yourself a revolution"—we in industry don't know how to identify, train and manage the 2 per cent.

If we could, in UK, know how to do these simple things this could represent a gain in national resource with wide ranging effects.

It is from these considerations, brought into focus by the need to address the questions raised by the Select Committee, that I have been drawn to the conclusion that an alternative form of initiative should be considered.

Management for innovation—a new initiative

The notes below outline an alternative approach to the perceived problems of innovation in UK industry in general, and may be felt to be a positive contribution to the debate.

Key factors in Industrial Innovation

My responses to the questions posed by the Select Committee have clearly identified common threads and these can be summarised as follows:

- Innovation initiatives can only be successfully generated within organisations.
- Innovation involves risk, and the management of innovation requires skills in the management of risk.

- The propensity to innovate is not uniformly distributed in individuals.
- That successful innovation within organisations depends upon:
    - Competence and confidence at all levels.
    - A methodology for the successful management of change.
    - A "seeding" of the organisation with selected maverick individuals to inspire change.

Without the first two of these attributes, sustained innovation is unlikely, and innovation rates will be undirected and unmanaged over time, with sudden "rushes of enthusiasm" being succeeded by a state of comparative inertia.

Without the third element, pressures to conform will always overwhelm continuous innovation within the organisation. Ideas will be generated, be ignored or fail to be pursued, fewer ideas will be generated in this hostile environment until inertia is firmly established.

Management for Innovation—an outline proposal

The notes below outline a proposal for a new initiative, involving both Research and Training, HEI and industry aimed at developing measurable improvements in innovation from within organisations.

It envisages the development of a programme involving both medium and small companies together with HEI's and other appropriate bodies.

The feasibility study to be sponsored and fully funded by Government.

OBJECTIVES

The Initiative would be directed to achieve:

- The development of industrially applicable methodology for the successful promotion and management of change.
- The establishment of practical methods of personnel selection to identify individuals with a natural propensity to innovate as a positive aid to recruitment practices.
- The development of specific training in innovation and its management to be included in technical tertiary education, and in industry.

STRUCTURE

FEASIBILITY STUDY

- To be conducted under the joint direction of a committed HEI and industrial executives.
- To be structured in two compact groups:
    - A research group—drawn from committeed HEI's.
    - An industrial study group—drawn from industrial company members.
- HEI membership should be limited to ensure rapid progress.
- The Industrial Study Group to include members from a NON-COMPETITIVE GROUP of companies sharing the same basic technologies, operating in different industrial sectors.
- The programme members to be drawn from a close geographical area to ensure effectiveness and coherence.

Commitment and Funding

It would be essential that, in order to obtain commitment, the Feasibility Study is tightly structured with:

- Full commitment by both HEI and Industrial company members to provide competent individuals with both time and resource to make a full contribution.
- A strict programme identifying time-scales for a structured series of progress reports to all members.
- A formal report and review procedure to the sponsoring Government agency.

Further Development

On the assumption that the feasibility is proven, it is envisaged that further development would take place in a similar manner, by creating a wider ranging programme and seeking to establish "cell" type structures of similar composition to the Feasibility Study, built on a regional basis.

SUMMARY

The outline above is not exhaustive, but indicates an approach to innovation specifically directed at improving the effectiveness of the UK management of innovation in all its aspects.

Its emphasis is on creating sustainable improvement rather than grant assistance, considers the whole spectrum of innovation rather than specific projects of limited initial value to the majority of UK companies (the small- and medium-sized established companies) and seeks to find ways to train and develop skills in innovatory management which will, if successful, provide a basis for long-term and widespread benefits to UK industry.

APPENDIX A

OUTLINE OF BRITAX AUTOMOTIVE COMPONENT DIVISION BSG INTERNATIONAL—PLC

Scope of operations

BSG International PLC (the Group) is a multi-national group operating in the UK, Europe, Australasia and the USA with a turn-over in 1989 of £639 million.

The Group's principal areas of activities are the responsibility of three main divisions, together with specialist support activities in Computer Services, Insurance, etc.

The three divisions cover, briefly, the following principal activities.

	Turnover £ million (1989)	Companies established in
Vehicle Distribution and Leasing Division	424.4	UK, Holland
Consumer and Special Products Division	100.0	
Childcare products Child Safety seats and restraints Nursery furniture, prams and pushchairs		UK, West Germany Italy
Aircraft Seating, Galleys and ancillary equipment Aircraft Toilet compartments		UK, USA

	Turnover £1 million (1989)
Automotive Components Division	
Original Equipment (OE)	
Vehicle Mirrors	46.6
Vehicle Lighting and Electrical	23.4
Vehicle Sunroofs	9.6
Other OE Sales	0.9
Total OE Sales	80.5
Other Non-OE Sales	34.2
Total Automotive Components	114.7

Britax Automotive Components Division

The division is responsible for all Group interests in the Auto components field of activity, both as suppliers to major Vehicle Manufacturers as original equipment (OE) and as a supplier to the specialist vehicle manufacturers and emergency services, as well as to the Aftermarket and Accessory market (AM).

The division has factories and/or sales companies in the following countries covering the Division's products in part or in total:

Vehicle Lighting Equipment		
Car Signal Lighting—(OE) Manufacturers	UK (2)	France
Commercial Vehicle Lighting and Emergency Service Lighting Equipment (beacons, etc.)	UK	Australia
Specialist Vehicle and Trailer Lighting	UK	Australia
Switchgear	UK	Australia
Wiper Equipment—Commercial Vehicles	UK	
Vehicle Mirrors		
Internal and External Rear View Mirrors—Cars	UK	France Australia USA
Commercial Vehicle Mirrors		
Vehicle Sun Roofs		
Glass Sunroofs—OE Manufacturers	UK	France W. Germany
Car Companies AM operations		
General AM for vehicles accessories		

In other, currently less significant markets, we use agents as an adjunct to normal direct selling activities.

Distribution of Turn-Over—Original Equipment (OE)

The distribution of OE turn-over of the Automotive Component Division can be summarised as follows (output from nine manufacturing locations).

Original Equipment (OE)	£ million
UK	34.1
France	18.6
Australia	13.5
W. Germany	11.1
Other	3.2
Total	80.5

Customer Base

The Britix Division is a supplier to most main line car manufacturers in Europe, to manufacturers in Australia, and is in the process of establishing a USA facility to provide, initially, mirrors to Ford and Chrysler for Original Equipment based on Britax designs originated in Australia.

The following list represents the current customer base of the Division for Original Equipment.

Original Equipment Sales (1989)	£ million
Ford	23.2
Peugeot/Citroen/Talbot	15.9
GM	9.9
Rover Group	8.1
Nissan	6.5
Renault	3.8
Toyota	2.5
Mitsubishi	1.4
	71.3
Other OE Sales	9.2
	80.5

BACKGROUND

Operating Structures

The Group has decided, in view of the geographical dispersion, and the need to maintain growth, that the optimum route to achieve their objectives is to maintain to the greatest extent possible individual company autonomy.

Resources have been directed:
- To markets we know and customers we understand.
- To provide a responsive and innovative approach to our customers.
- To be quick to answer customer needs.

In this we have been successful, as our gains in new business from new customers during the 80's have demonstrated.

We are, moreover, able to face our (not withstanding 1992) basically "nationalistic" European customers and competitors with local direct support and capability managed by local nationals supported by Group expertise.

Strategy in the Automotive Components Division

During the 80's Britax Companies have concentrated efforts on:
- Products with high technical content.
- Developing our design expertise in specialist product fields.
- Broadening our product, customer and manufacturing base to be represented in the World European Industry on the widest possible front.

Today, it would only be a slight exaggeration to say that we now sell our technical expertise in our chosen product field first, the actual orders to supply follow.

As a consequence of following this approach, we have been successful in making progress towards our major objectives. Our customer base has significantly broadened and new prestige contracts won against entrenched opposition.

New contracts with **Ford** (supplies to the New Fiesta), and **General Motors** (New Cavalier) have been obtained against established and larger European competitors, whilst supplies to **Nissan** and **Honda** have been gained against significant international competition. In France we are the major suppliers of mirrors to **Peugeot/Citroen,** whilst our established European business with **Ford** has continued to grow.

Outside Europe, acquisitions in 1988 in Australia have provided a springboard for obtaining major contracts—**Chrysler,** and for the supply of mirrors to main line US auto manufacturers resulting in the decision to establish a manufacturing base in the USA.

International Co-operation/Licensing

In order to further broaden both our technical base and our international competence we have tended to change the emphasis from our traditional licensing stance, seeking in addition to establish informal links with overseas companies.

We have long standing associations with comparable companies in Japan and the USA, where we felt specific advantages could be gained, and have made significant investment in management time to maintain a relationship and co-operation on items of mutual interest.

SUMMARY

In summarising the Company background above the following represent the key items around which Britax Automotive Components had built an organisation which is acknowledged to be successful in the supply of Automotive Components to customers on both a European and world wide basis.
- Specialisation in product terms to direct our resources to products where we are accredited competitive specialists in both technical and manufacturing terms, on an international basis:
- Providing a resource which can effectively represent Britax Automotive Components in a way which acknowledges the differences between our customers in both commercial and technical matters.
- Providing where necessary local resources and management, and being prepared to provide local manufacture where appropriate.
- Matching our customers' varied Design Philosophies and Quality Standards and providing local technical competence backed by total Britax Automative Division resources.

Levels of Innovation

As I have indicated, one result of this approach, and the strategies and philosophies we have adopted, places restrictions on our "pure" research.

Our R&D is decentralised, and directed to meet specific customer needs and preferences, and to providing specific solutions to customer problems at economical cost. Whilst customers look of technical competence, they are not always forthcoming in paying for development. We on our part, have had some bad experience in development work and know-how initiated by us being passed, together with the production order, to competition.

We have sought to maintain a steady flow of innovation, and development programmes have been undertaken on a number of key product areas—for example:

- Remote control systems of external mirrors, motor driven, hydraulic and other non-motor drive mechanisms.
- Development of CAD designed optical components for vehicle lighting. Lights have been made from CAD computer tapes from our customers representing the body to which the lamp has to match, and the final lamp produced without there being any intermediate physical representation of the product.
- Development of plastic moulding technology using CAD tool design with CAM tool manufacture, coupled with extensive use of sophisticated process control techniques.
- Heavy investment in both techniques and training to assure Quality at all levels, with operators conducting all first line quality control and concentrating on defect prevention and zero defect manufacture.
- We are a contributing member of the European Eureka (DTI INFACT) project, a consortium of companies and technical resources both in UK and in Europe, the project having as its objectives the development of fully flexible automatic assembly technology of small mechanisms.
- Carried out and developed revised forms of manufacturing organisation and staffing to improve factory performance and reduce levels of management.
- Supported progress with significant capital expenditure:
    - CAD/CAM (Computer Assisted Design and Tool manufacture).
    - Substantial re-equipment and updating plastics moulding facilities.
    - Investment in three-colour moulding for rear lamp manufacture.
    - Computer aided systems for planning, Manufacturing planning and control and Quality Control and testing.
    - Computer simulation techniques.

R&D Resources

As a Division some 10 per cent of our overhead is spent in Research and Development activities, excluding Production Engineering and Quality Control.

APPENDIX B

GLOSSARY

AM — After Market
The market for components as spare parts or accessories for distribution to owners of vehicles.

CAD — Computer Aided Design.

CAM — Computer Aided Manufacture.

FMEA — Failure Mode and Effect Analysis
A method of analysing product design before tooling is commenced to establish the integrity of the design and its ability to carry out the task required.

OE — Original Equipment
The supply of parts/components directly to the vehicle manufacturer for incorporation into vehicles during the vehicle assembly operation.

Memorandum by The British Clothing Industry Association Clothing Technology Centre

1. Industry/Company attitudes and structures

In considering innovation (presumably, in manufacturing, the task of converting an invention into commercial profit) it is clearly of fundamental importance to understand the nature and structure of the sector concerned. The Clothing Sector is characterised by a high ratio of small- and medium-sized enterprises (SMEs) to large companies. There are 61 SME clothing manufacturers employing between 20 and 500 people for every one employing over 500—this compares with a 22:1 ratio for all manufacturing industry. Even the large companies are almost all decentralised agglomerates of SMEs and none has any significant scientific research resource in-house.

The key innovative tasks of the clothing manufacturers are product creation and development and the harnessing of manufacturing resources to deliver to the retailer the correct goods at a competitive price at the required time. To achieve these targets often requires the manufacturers to use high technology tools. These tools are normally developed by commercial machinery companies as individual clothing manufacturers do not have the necessary expertise or resources.

The product itself—a garment—would not normally be seen by the consumer as a "high technology" product. In practice considerable technological skill is necessary in the product design and development area to ensure that the aesthetic/performance/price delivery balance is optimised.

One challenge to the clothing manufacturer is the correct selection and efficient implementation of new technological tools. The majority of companies are not large enough to have a "task force" approach to this challenge, i.e., they do not have the resource to set aside a small team to assess available new equipment and systems and then be responsible for the implementation of them in the factory. Usually it is a "spare time" task of the supervisor/engineer or factory manager who in practice have very little "spare time".

The research strategy that is appropriate for a consumer goods industry comprising mainly SMEs is fundamentally different from the appropriate strategy for large company or high technology based industries. A table indicating the differences is attached as Appendix I.

In summary the key innovation expertise required by the clothing industry is in product design and development and in the selection and implementation of new production technologies—wherever developed. An important element of product design and development is to link design and production processes with fabric properties—this is an important area for research.

2. External/overseas technology

As covered in 1 above, clothing manufacturers do and can do, very little in the area of production technology R&D (except for limited areas covered by the Clothing Technology Centre—which was established by an initiative of BCIA in 1987). The bulk of their production technology must, therefore, come from external sources.

Regrettably there are relatively few UK manufacturers of garment making machinery—a high proportion of equipment coming from overseas. A substantial number of clothing manufacturers (estimated at approximately 30 per cent) will send personnel to the tri-ennial Clothing Machinery Show in Cologne.

Materials technology is also of obvious importance and new materials such as the "microfibril" based fabrics will offer important opportunities for product innovation. This again is "external" technology and again has a large overseas component.

3. Product development and production engineering

Product Development has been highlighted above as probably the key area requiring expertise in the clothing industry. It, of necessity, embraces the need for thorough market knowledge linked with design expertise) aesthetic and performance).

Production Engineering in its broad context is becoming increasingly important with the emphasis moving at present from fairly inflexible, highly automated systems to less automated but more responsive systems. The international cross sectoral movement towards "World Class Manufacture", "Just-in-Time" and "Total Quality Management" has affected priorities in the clothing industry.

An important study in a similar consumer goods sector, on the effect of repeat order delivery time on retail profitability, showed the dramatic effect that optimising repeats could have on the retailers' business. Initial calculations based on data from a clothing retailer suggest a similar picture. The results show that retailers could afford a significant premium to purchase locally made goods—provided the local manufacturers can "gear up" to provide a fast and reliable repeats service. If this is linked with providing small sample runs of new styles for test marketing the rewards are even greater.

The logistics for this approach require a high level of production engineering skill. Such emerging technologies as computer simulation of production will be key tolls in this evolving strategy.

4. GOVERNMENT SUPPORT FOR INNOVATION

In the past the DTI support for innovation through the "Support for Industry" initiatives was very helpful for the Co-operation Research activities for these SME type industries. Subject to approval by the appropriate Requirements Board, funding, normally at 50 per cent of the cost, was available for the R&D stages from conception through research into development and on to the stage of having reasonably "de-bugged" products, services or knowledge. They were then developed to a stage where the management of a SME having a "good average" competence could assimilate them.

Current DTI policy with its emphasis on "far from the market" research and tapered funding, while perfectly funding logical for the contract or club type research for large companies, is resulting in a reduction of the research base for the SME, consumer goods type industries. It also reduces the incentive for the vitally important but more prosaic work of "de-bugging" and "fine tuning" developments as they near the factory floor.

5. CITY ATTITUDES

It is an often quoted truism that the City is blighted with "short termism". It may be interesting (if it hasn't already been done) to select a fairly wide range of successful commercial products and analyse the cash flow (in real money) from the point of first spend on research to the point of first sales and on to the point of peak cash flow in. This analysis should not only highlight the time scales involved but also the need for continual R&D investment long after the first sales are made. We would be surprised if the "median" time between first spend on research and first sales was less than four years or, assuming the product is commercially viable, if spending on R&D ceases in less than a median of eight years.

It does appear that the risk/reward and investment time/return equations in Germany and Japan have different indices from those used by the City.

6. EFFECT OF LEGISLATIVE AND REGULARITY FRAMEWORKS

There is little doubt that the dominant factor in deciding the industry's expenditure on equipment and new innovations is its profitability at the time. This is clearly dependent on many factors but some of the major ones are outside the control of the industry itself—for example the exchange rate. The average profitability of one UK consumer goods industry in a given year plotted against the ratio of Sterling to the US dollar for the previous twelve months gave a very significant correlation co-efficient of .72 even though this is obviously a very crude measure.

Confidence in a longer term future is also an important factor in investment decisions. The current uncertainties about the outcome of the MFA and GATT negotiations are bound to cause some unease.

A few years ago the Australian Government introduced an incentive scheme to encourage R&D by allowing 150 per cent of the R&D cost against taxable profits (recently extended until 1993). This may be difficult to monitor for "in-company" R&D where the companies do not have defined R&D facilities. It would presumably be very easy to monitor on research costs spent outside the company at Higher Education Institutes (HEIs) or Research and Technology Organisations (RTOs). This could give a boost to the "Industrial Research" industry in the UK which is already generating significant export earnings in addition to providing a major resource for UK industry.

7. TECHNOLOGY TRANSFER FROM HEIs, ETC

The short answer for an SME type consumer goods industry is that the mechanism for technology transfer from HEIs into industry are not effective. There are several reasons for this. Firstly, relatively little research is carried out at HEIs or Public Laboratories that is directly relevant to a clothing manufacturer. Secondly, where relevant research is done, the HEI cannot normally take it to the development stage where it is assimilable by the "averagely competent SME". Finally, in the area of technology, there is an inherent communication problem between a researcher at an HEI and the factory management—they live in two different worlds.

One of the motivations that BCIA had for developing the Clothing Technology Centre was to provide a vehicle to bridge that gap.

8. EEC SUPPORT

Most of the current EC initiatives, e.g., BRITE suffer from similar limitations for the SME consumer goods industries as does the current DTI initiative. That is the emphasis is on long term, high cost, high risk research but with the added complication of transnational co-operation. Again this is clearly a well used route for funding by large technically orientated organisations.

An interesting development in the EC's initiatives is the CRAFT project (Co-operative Research Action for Technology) which is specifically directed at research for "traditional" SME industries. In its initial form it has an Achilles' Heel in that it talks of funding single projects. If this can be extended to cover the funding of a coherent programme of projects—to give a broader appeal to a wider range of companies, it could be a valuable initiative for our type of industry. (The single project concept would require individual firms to be approached to fund that one project. For a consumer goods SME industry it would require two or three visits to each of two or three companies before one agreed to contribute a few hundred pounds to the project. By that time the "marketing" costs of the project would have exceeded the contribution sought!) With the programme approach the companies annual subscription to their RTO can be used for the industrial contribution. A small selected group of industrialists would be responsible for programme definition and monitoring.

A potentially valuable project has been submitted to DGXIII under the SPRINT programme to assist co-operation between the key EC Clothing Research Centres. The outcome should be known by the end of this month.

As a general point on EC funding it must be said that laudable though the Commission's initiatives are for promoting transnational co-operation, it is inherently less efficient than nationally supported research for our type of industry.

9. SUPPLIERS' ROLE

(a) *Material and component suppliers*

The UK has a substantial textile supply industry with over 1,000 companies employing 50 or more people. Even so, less than 50 per cent of material used by the Clothing Manufacturers is produced in the UK.

The increasing emphasis on the need for Quick Response to meet Retail demands puts a premium on the importance of a strong domestic supply industry. Electronic links between retailers and manufacturers and suppliers are also growing in importance.

(b) *Technology suppliers*

The Clothing machinery and process supply industry in the UK has shrunk considerably over the past few decades. It is doubtful whether initiatives aimed at creating a major resurgence of the machinery industry could be successful. There are, however, a number of entrepreneurial companies who "custom" modify equipment for individual company requirements.

(c) *Retail customers' role*

There is a pleasing movement among the UK apparel retailers towards more sophisticated product costing—taking into account the true cost of importing and the sales lost from shortages of fast sellers, etc. There is, however, a long way to go in many retail companies before there can be truly commercial premiums and penalties for varying qualities of service from their suppliers.

10. INVESTMENT IN INNOVATION

Inevitably and correctly, many factors contribute to investment decisions. In practice, two dominant factors are—this year's profitability and next year's outlook. A further significant factor is—what are my competitors doing? In practice these are often more dominant than the more obvious questions of potential return on investment and level of investment.

Two other, often not consciously calculated, factors are: "What resource have I to effect the implementation of this new technology?" and the likely "hassle factor". This latter point is rarely considered in any quantified way but has a major effect on decision making.

Companies with longer time horizons would clearly estimate the long-term trends in their industries but attempts to predict long-term interest rates or exchange rates (which can have a dramatic effect on the business) are very risky.

11. DEFENCE R&D AND THE CIVIL SECTOR

We are not aware of any research carried out "in-house" by MOD establishments that has had a direct spin-off into the Civilian sector. Where research has been contracted out to an Independent Research and Technology Organisation and been cleared by MOD for release to the Civil sector, there has been effective transfer. A good example of this was the development of a water vapour transmitting film of polyurethane that "breathed" while being completely waterproof. This has been licensed and is being exploited commercially by a British company.

J B Butlin
3 *April* 1990

APPENDIX I

Nature of co-operative research versus contract research

	Co-operative Research (Membership based, e.g., Clothing Technology Centre)	Contract Research (Project based) (Can be a single company or collaborative club)
Customer Type	90 per cent SMEs.	Larger Companies
No. of firms supporting	400	1 – 10
Available interface expertise in company	Practical factory management	Scientific or strong technical/engineering
Development stage required for acceptance	Available for fairly trouble free implementation to factory floor without major production hold-ups.	Can be picked up at working prototype stage or even earlier.
Implementation resources and Skills	Very limited, usually part-time additional "responsibility on managers' shoulders".	Usually have qualified staff that can be seconded full-time to project implementation.
Commercial Assessment of economics of a single R&D project	Required skills and information not normally available in many SMEs. A small group of selected individuals give balanced judgment.	A necessary requirement for the funding of any contracted research.

Memorandum by the British Footwear Manufacturers Federation

I. BACKGROUND

The Shoe Industry

In order to understand how innovation operates in the UK Footwear Industry it is useful to understand something of the background of the business.

(1) Though the British industry has traditionally consisted of small companies, there are increasing signs of concentration and some large groups with an increasingly international outlook.

(2) There is a huge volume of international trade in footwear, the flows of which are very sensitive to changes in costs and prices.

(3) The industry has been under constant threat from imports for the past 25 years from all parts of the world; this has led to a considerable shrinkage in capacity and employment.

(4) For some sectors, notably the higher quality men's, the British industry is a substantial exporter.

(5) On the whole because of the craft traditions of the industry the rate of innovation has been relatively slow but never non-existent. In some areas such as adhesives the shoe industry has been ahead of other sectors because of the peculiarities of materials and processes.

(6) Some of the larger companies have been considerable, even world class, innovators. But import pressure and other financial problems have reduced their capacity to innovate. Some smaller companies too have been very progressive.

(7) A brief period of prosperity during 1985-88 after long years of decline produced a flowering of innovation and investment. Subsequently, however, a number of those who had innovated and invested went into liquidation.

(8) Innovation is not an automatic key to success in the industry. Indeed one of the overall most profitable and successful group of manufacturers, the craft based men's high grade welted shoemakers, are the least innovative. Partly this is due to the fact that they use a complex manufacturing system that is not much used elsewhere and has, therefore, attracted little development by the machinery companies.

(9) At present foreign investment by the industry is very limited.

II. WHAT IS INNOVATION?

Their terms of reference make clear that it is not the function of invention. We would like to set out what we understand by innovation in further detail.

Much of the most productive investment that shoemakers can make is the installation of equipment that is new to their factory and which is known to be likely to produce a rapid payback possibly in under one year. This can involve technologies which are quite new or which have been around for some time. Whilst this is an activity which is greatly to be encouraged we would not define this as innovation for the purpose of this submission.

We would define innovation as the adoption of technology where there is a degree of uncertainty about the length of payback of the technology, or where there is a chance that the technology may not significantly reduce costs but allows further long-term progress to be made.

To give an example, the companies who installed CAD systems in the shoe trade in the mid-1970's were innovators. The payback was probably no better than 8-10 years but they made the investments at very inflated prices in those days, because they regarded it as the key to long-term development of computer aided shoe making.

Those companies that have bought CAD systems at a tenth of the price (in real terms) during the last three years and have been able to see instant results and 1-2 year paybacks are not innovators.

It should be pointed out that innovation is not only to do with machines, it can be based on creative working systems.

III. THE INTERNATIONAL AND NATIONAL FACTORS WHICH ENCOURAGE INNOVATION

By defining innovation in the way we have done we imply that innovation involves taking risks. Therefore, investment in new technology is more likely to take place when:

(1) There is a prospect that the demand for the company's products will remain stable or increase. This implies that the demand for the company's products will not be adversely affected by factors beyond the company's control such as:

- (a) Stop/go economic policies leading to wild fluctuations in domestic demand.
- (b) Volatile exchange rates which suddenly make exporting much less profitable or alternatively make competing imports cheaper.
- (c) A situation of long-term decline in the industry.

(2) There is a financial environment which encourages the making of investment and taking of risks which involve taking a long-term view:

- (a) The cost of borrowing is relatively predictable over say a three year period.
- (b) Where a company is dependent on publicly raised funds it should have access to lenders who are prepared to take a long-term view.
- (c) Alternatively there should be a financial environment which makes it easy for companies to remain private and thus be able to be independent of the "quarterly statement" mentality of many financial institutions.

IV. THE COMPANY CULTURAL CHARACTERISTICS WHICH ENCOURAGE INNOVATION

(1) From what has already been said it is obvious that the ability to take a 4-5 year financial viewpoint is crucial. In the shoe trade this is most likely to occur when the company structure is one of the following:

- (a) A strong and united private company.
- (b) A public company dominated by a few individual shareholders.
- (c) The subsidiary of a cash rich conglomerate which can afford to take a long-term point of view on certain sectors of its portfolio.
- (d) A company dominated by a single entrepreneur.

It is least likely to take place when:

- (a) The company is part of a disinterested public group which is under constant pressure to produce improved results.
- (b) In a company that has been the subject of a heavily leveraged buy out because this reduces the financial resources available.
- (c) Where a small family business is just being kept going to provide a living for the owning and managing family of the current generation with no plans for a long-term future.

(2) Above everything the management must have a belief in "making things" rather than being a property developer or shopkeeper. For many years retailing was a siren voice for many footwear companies because it was much easier for someone of limited ability to make money in retailing rather than in manufacturing. This, of course, is no longer true but it takes a long time for attitudes to change.

(3) Innovation generally depends on the company having competent technical management who really understand where they are trying to go; otherwise there is a risk that much money will be wasted. This implies that the company will have been prepared to invest in people and their training.

(4) It is rare for an innovative company to have top management that does not take a real interest in the company's technical progress. In shoemaking innovation is a very "hands on" process.

(5) A company needs to have a large scale financial vision. This is a major problem in the shoe trade (on a world wide basis) where most shoemakers are conditioned to think in terms of machines which cost around £40,000 each at most. The only exceptions are the moulded footwear makers who are used to equipment costing up to £400,000.

A good deal of truly innovative modern equipment costs much more than £40,000 and this creates problems.

V. SOURCES OF NEW PROCESSES OPEN TO UK MANUFACTURERS

(1) Most importantly much of the most sophisticated shoemaking machinery is developed and built in the UK.

(2) UK shoemakers are also well served by competent agents of foreign shoe machinery suppliers and are generally well aware of what is becoming available.

(3) The UK Shoe Trade is served by the world's best overall shoe trade research group SATRA, which not only innovates particularly on the systems side but is able to provide from its world wide connections information on what is going on in other countries.

VI. UK AND EUROPEAN GOVERNMENT INFLUENCES ON INNOVATION IN THE SHOE INDUSTRY

From what has already been said it is obvious that:

(1) The wild fluctuations in the level of sterling are a major discouragement to innovation.
(2) The violently fluctuating rate of interest in the UK discourages the taking of long-term innovation risks.

However:

(3) The tax regime in the UK causes no problems to genuine well thought out innovation.
(4) The employment laws and unions are also no problem. In fact the UK situation is better than many.
(5) Government policies and schemes for advice, grants, etc., are misconceived and unproductive.

The problems relate to the following:

(a) There are too many schemes, they change too often and are therefore not well understood.
(b) They are much too restrictive on grounds of such things as:
    (i) Regions eligible.
    (ii) Activities within the company that are eligible.
    (iii) Size of company eligible, i.e., no company employing over 500 people.

Our view is that these grants have not been and are not likely to be of much use to any well organised innovative company.

Furthermore making people believe that there is money available may be actually dangerous because it encourages people to do one of the following in order to try and get a grant.

(i) Delay the start.
(ii) Invest in projects which will be grant eligible.

In general the French government seems to have had some useful schemes for encouraging innovation in the shoe trade and we believe these are worth studying. In particular those which assisted in the rapid early adoption of CAD and the insurance scheme that exists between the supplier of a new technology and its early customers. This latter is effectively a risk reduction formula.

(6) UK shoe companies have not been involved in recent joint EEC financed development programmes. SATRA has been involved. However, from a manufacturers point of view these joint programmes have tended to be more "inventive" than "innovative" in that they involve the creation of entirely new technologies which then require some manufacturers to take them up.

CONCLUSIONS

The real key to successful innovation by the British Shoe Industry is a stable and predictable economic background where manufacturers believe they have a long-term chance of survival. This clearly implies different policies on the exchange rate and interest rates than those that have been used for the last 30 years. Membership of the EMS is clearly a priority.

There has been a significant change in management in the industry over the last 10 years and many of the new managers are young and more forward looking.

The question is what further assistance government can give other than the priceless assistance of relatively stable interest and exchange rates and easy access to long-term funding.

If grants or assistance are going to be provided for innovation they must be simple and universal; it is ridiculous to exclude any company employing over 500. These are the most likely innovators.

A study should be made of ways to reduce the risk/cost of the true innovator who is the first to take a risk and has a long-term view. There should be risk insurance on the French basis or possibly a substantial grant/tax rebate to the first or first few users of a new technology. At present the incentive is to wait and see and let someone else try first because probably the price of the equipment and its software will fall once the bugs have been sorted out. Hardly an attitude to encourage innovation by manufacturers, or even invention by the equipment suppliers.

17 *April* 1990

Letter from the British Radio and Electronic Equipment Manufacturers' Association

The Association wishes to offer the following brief comments:

(a) *Technology and Training.* All innovative development stems from technology. It is in this field, both in education and in training, that the UK lags behind its foreign competitors, both in the numbers of engineers trained and also in their re-training to meet a fast-moving technological scene.

(b) *Finance.* There is strong evidence that the City's short-term outlook in Britian tends to stifle risky innovation. This is less true in other countries where long-term finance is more readily available without the requirement for instant results.

(c) *Incentives.* HMG could offer more favourable tax incentives both for Research and for development to help combat the disadvantages of (b) above. In most cases where this has occurred, innovation has flourished.

(d) *Commitment.* In some cases good innovative products fail to take off because of the chicken-and-egg approach to expansion. The case of UK's teletext service was one such which was stimulated by HMG's active involvement, which included favourable tax incentives, and the whole of industry's commitment to make it succeed which involved broadcasters, set makers, chip manufacturers and the distributive trades. The result was that the UK teletext standard became a world standard and a real success story.

(e) *Level Playing Fields.* Too often British industry competes with others for whom their governments do more than HMG which has tended recently to prefer a totally hands-off approach. In certain areas we believe governments do need to provide some pump-priming. In others they need to provide a regulatory framework to prevent a proliferation of systems such as has grown up in the UK's satellite broadcasting services where programmes exist in different technical standards with a multiplicity of incompatible encryption systems. Our European Association has called on Mr Delors to consider setting up a Regulatory Authority to prevent this recurring. In the field of unfair trade the British government is seen as being far less supportive to producers than others in preventing abuse.

(f) *DTI—Industry links.* The historic links between sectors of industry and the DTI have now been abolished following Lord Young's re-organisation in 1988 and completed by Mr Ridley in 1990. This will ensure that officials in the DTI have a very imperfect understanding of most industries. It is debatable whether this is a good thing.

(g) *EC.* The plethora of legislation emanating from Brussels in advance of 1993 must also make innovation for producers more difficult at this time. This is in stark contrast to the lack of regulation in satellite broadcasting mentioned in sub-paragraph (e) above.

I hope these brief comments may be of some use to the sub committee.

O P Sutton
Director
15 *May* 1990

Memorandum by British Steel

British Steel is the second largest steel producer in Europe, and is the fifth largest in the western world, and during 1989 produced 14.21 mt of crude steel. The company is technologically based and depends on innovation to stay competitive in the world market. Of 53,200 Company employees in the UK on 1 April 1989, approximately 31 per cent (16,800) were in the Technical and Engineering function, of whom 11,000 were craft or manual workers, and 1,700 professional engineers. Within the Technical and Engineering function, there are a total of 3,000 graduates (or equivalent).

The Company has four corporate laboratories and small business laboratories which together employ over 1,200 staff.

The research and development budget for 1989-90 was £32 million.

The questionnaire has been answered from the industry's point of view.

In summary, the main points are as follows:

(Q1) British Steel is technologically based, and the Company aims to introduce technological innovation through its capital investment programme, to reduce overall costs, improve productivity, improve the control of process operations, and improve product quality. The structure of the Company, which is under constant review, ensures that investment decisions are taken in the light of all the relevant technological information. Personnel and other policies are not unnecessarily restrictive.

(Q2) To achieve Company objectives, British Steel has a policy of investing in "world-best" technology, which means that, where appropriate, technology is purchased overseas.

(Q3) Product developments are carried out to meet revised market requirements, seek out new markets, and retain or enhance market share against competing products.

(Q4) Prior to privatisation, the ability of British Steel to benefit from Government financial aid for innovatory technology was constrained by external factors. However, effective support has been received for a number of "non-mainstream" activities, and as a private company it is expected that such support will be enhanced.

(Q5) At first sight it appears that the City views technical advance positively, but few analysts have any technical knowledge and thus their critical appreciation of the technologies involved is open to serious question.

(Q6) Legislative regulations on labour costs, patent laws and tax concessions are effective in supporting R&D.

(Q7) Technology transfer from HEIs, Research Councils and public laboratories makes only a minor contribution to the introduction of innovation in British Steel.

(Q8) British Steel derives significant benefit from EC support in the area of technological innovation and pilot plant development.

(Q9) There is a danger that contact between British Steel and some of its suppliers can lead to a dissemination of in-house technology to competitors.

(Q10) Although British Steel's manufacturing and R&D base is in the UK, use is made of expertise and facilities elsewhere in the world if appropriate.

(Q11) Financial support which British Steel receives from MOD for work of the type outlined in the ACOST report, is insignificant.

Q1 *What are the effects of company attitudes and structures (including personnel policies, investment decisions)?*

A. The company attitude towards innovation is positive and this shows in the investment programme. Personnel decisions are not unduly restrictive in that a special case can always be made to obtain a first class technical man or to maintain a highly skilled team.

The company policy and strategy is determined by the Board, which is chaired by Sir Robert Scholey and consists of Executive Directors, (the Chief Executive, the Chairmen of the main businesses (Strip Products, General Steels, Stainless and Distribution) and the functional Managing Directors of finance, personnel and technical) and Non-executive Directors. The Management Co-ordinating Committee (MCC), which is chaired by the Chief Executive, Mr Martin Llowarch, implements the Board's policy. At the core of the MCC are the Chairmen of the main Businesses and the thee functional Managing Directors. The Directors, R&D and Engineering are also members and the Director, Engineering is also a member of the Chief Executive's Planning Committee.

In the individual Businesses, each Works is under the control of a Works' Director, who sits on the Business Board, which is chaired by the Business Chairman. In addition, Works' Chief Engineers are functionally responsible to the Director, Engineering (who is responsible to the MD, Technical) and Works' Chief Metallurgists are functionally responsible to the MD Technical. Policy is thus transmitted from the Board to the Works down the line and functional routes, which also pass information back up the system to the MCC. Transfer of information decisions and directives in each route is thus helped by common membership of the various committees and there is minimal opportunity for misunderstanding policy aims.

Technical matters are therefore considered at all levels in the Company, together with factors related to personnel and investment policies. British Steel's capital investment programme, which often involves the introduction of innovatory technology, is aimed at upgrading and rationalising production facilities in order to improve productivity, product quality and customer service, to reduce costs and to widen the product range. The Company regularly updates a Technical Strategy report which *inter alia* highlights those investments necessary to attain world class competitive capability.

Q2 *How active are UK companies in seeking out external technology, especially from overseas? How well do they adapt and apply it?*
A. Where appropriate British Steel purchases overseas technology, either via Plant Manufacturers, where capital equipment is involved, or by licencing where new products are concerned. In most cases adoption of the technology is smooth, largely because there are often direct links between British Steel's technical and engineering staff and the steel company selling the licence. On most occasions, British Steel Technical will have parallel or competing technology such that it has a sound understanding of the specification and requirements of the new technology.

It is a firm policy of the company to establish an in-depth technical involvement in any major schemes as a result of serious problems with plant purchased in turn-key contracts, particularly in the mid-1970s. Experience has shown that, without this in-depth involvement, translation of purchased technology through plant suppliers would still be deficient. There are a number of instances where British Steel has developed the purchased technology to outstrip that from the initial supplier and has generated income from subsequent technology sales.

British Steel also has a number of technical exchange agreements, perhaps the best established and widest ranging, being that with a Japanese steel producer, which covers all aspects of steel products and processing.

Q3 *What are the respective roles played by product development and production engineering in technological innovation?*
A. Because of the nature of its products, British Steel is not engaged in production engineering. However, process development can lead to technical innovations which will reduce product costs by reducing energy consumption, improving yield or eliminating stages of the process route. These developments can often be introduced independently of product considerations but could have product benefits such as improved consistency or improved quality. In the case of more radical process development changes, e.g., replacement of ingot casting by continuous casting, or exclusion of a processing step, e.g., direct casting of sheet products, it may be necessary to develop a new product (steel specification) to achieve the same degree of customer satisfaction (product acceptability) via the new technology.

Product developments are undertaken either to meet revised market requirements, seek out new markets or to retain or enhance market share against competing products. In many cases the new product can only be introduced in association with changes in the processing route, themselves sometimes quite extensive and costly, which in turn can demand innovation in process control engineering.

British Steel has a number of end product development centres, including a press shop for automotive steel development and design, and a can shop for tin plate packaging developments, at its South Wales research laboratories. A coated products development centre at Shotton Works is devoted to structural applications and consumer goods. Three of the four research laboratories are engaged in product development work for specific product areas.

Q4 *How effective are the activities of Government Departments in promoting and supporting innovation?*
A. Prior to privatisation in November 1988, British Steel's ability to benefit from Government financial support for innovative technology was constrained by external factors. However, there were a number of isolated instances where effective support was received for "non mainstream activities", and as a private company it is expected that such support will be enhanced.

Examples of collaborative work and support are:
Department of Energy: There are many examples of very effective collaborative work with this Department and ETSU on energy efficiency demonstration schemes in the process engineering area. There has also been a number of product developments involving oil companies and British Gas on offshore steel developments of pipelines and topside modules.

Department of Environment: Support for use of steel in domestic housing and steel developments and design innovations on use of steel in construction from the aspect of safety from fire risk.

Department of Industry: Involvement with the Process Plant Association, a group of UK fabricators, on steel developments to aid fabrication via hot and cold forming.

Q5 *What are the effects of City attitudes to investment in innovation?*
A. Judging from the comments of financial analysts visiting our laboratories and works, an effective R&D organisation and technologically advanced plant are seen as strongly indicative of an efficient company. It should, however, be said that many analysts have little knowledge of the basic technologies involved and therefore cannot apply any critical analyses to what they see and are told.

Q6 *What is the effect of the legislative and regulatory framework concerning, for example, labour costs, patent laws and tax concessions on R&D and the purchase of know-how?*
A. Labour costs
Legislative regulations on labour costs do not impose any constraint on R&D and the purchase of know-how.

Patent Laws
Patent laws do not provide an obstacle to innovation since they are designed to reward such innovation by the grant of a limited period of monopoly (20 years) to the innovator.

In recent years, perhaps one of the most beneficial moves in Europe has been the adoption of a single application to the European Patent Office (in Munich) by which, following a common examination procedure, acceptance of the application leads to the grant of separate patents in the various European countries orginally nominated. This procedure is shortly to be improved by facilitating the grant of a single "Community" patent, i.e., instead of having a bundle of patents, each effective in various countries, a single patent effective throughout the Community as a whole will be granted.

A further significant move has been in the field of copyright where a hitherto anomalous situation had subsisted, by which protection for this "unregistered" right was superior to that which could be obtained by patenting in some circumstances. The new Copyright, Designs and Patents Act (1988) has rectified this by creating a "design right" for articles of manufacture previously embraced within copyright in respect of which a fairer period (15 years) of protection now exists.

Tax Concessions
A full tax write-off in the year incurred is available in respect of capital expenditure for Scientific Research (i.e., "any activities in the fields of natural or applied science for the extension of knowledge").

The cost of acquiring rights in, or arising out of, Scientific Research is excluded from the tax relief for Scientific Research. This would include the costs of acquiring Patents and know-how for which a tax write-off of 25 per cent per annum is available for setting off against taxable profits. The tax legislation therefore, gives a higher rate of allowance to the initial Scientific Research expenditure than it does to any subsequent "safer" capital expenditure on assets arising out of successful research.

In a press release of 20 July 1987, the Revenue announced the publication of a joint study with the Treasury of international fiscal incentives for research and development spending.

The major conclusion was that special fiscal incentives were not cost-effective in the UK and the nine other OECD countries studied—the value of additional research and development spending only amounting to roughly one-half of their cost to Governments in revenue foregone.

The results of the joint study were part of the Government's overall response to the House of Lords' Select Committee on Science and Technology recommendation that the comparable tax incentives of other countries should be examined. The implication is that the present generous tax relief available for Scientific Research could be restricted in future, which would be unfortunate.

Q7 *How effective are the mechanisms for technology transfer from HEIs, Research Councils and public laboratories to manufacturing industry?*
A. The mechanisms for technology transfer are mainly via personal contact following identification of activities of common interest.

In recent years HEI's have had increasing difficulty in obtaining Government funding for steel-related research and hence, despite there being expertise available, there is a reducing level of activity in areas of steel processing and steel development. British Steel has continued to fund collaborative work at a number of HEI's via CASE awards and direct sponsorship and has taken new initiatives at selected Universities in funding a Chair, lectureships and supporting teaching company schemes. Included in the direct funding arrangements is some support for sponsored or directed research. The position is exacerbated by the multiplicity of departments in the case of metallurgy. Were the Universities to re-arrange themselves so that say, three or five major schools resulted, finance from industry would be more readily available.

There are few examples of effective transfer of technology from Research Councils.

Involvements with public laboratories have been small compared with the size of the laboratories. There has been effective contact with the Transport and Road Research Laboratory, particularly on steel safety barriers, and with the Building Research Council on structural design, steel cladding for buildings, bridges, floor panels and fire engineering. There has been a lesser contact with NPL on steel and fluxes phase modelling developments and with NEL on steel design and testing. There are many examples of joint work with laboratories receiving part Government funding, or with laboratories of companies in, or until recently in, the public sector. Particularly strong in this area is the contact with the Welding Institute and with the CEGB, BNFL and UKAEA in development of specific steel products.

Q8 *Does the UK benefit sufficiently from EC support for innovation? How might it be improved?*
A. The main EC source of financial support for innovation in British Steel plc is the ECSC Steel Research Programme. In 1989-90, the income British Steel obtained from all ECSC research projects was 4.84 million ECU (equivalent to £3.38 million). The funds for this programme are obtained from a levy on the European Steel Industry under the terms of the ECSC treaty. The Treaty provides that some of the income raised should be used to support a Research and Development programme. The British Steel Industry has participated in this Research and Development activity from the start. Several years ago, agreement was reached between the Industry and the Commission that a proportion of the annual research budget should be specifically allocated to support Pilot and Demonstration contracts, to encourage the application of the results of research contracts into pilot scale or production scale use for process improvements and the manufacture of new products.

Currently some 30 per cent of the annual Steel Research Programme budget is allocated to the Pilot and Demonstration Programme. For the contracts due to start in 1990, this amounted to 13 million ECU. British Steel plc had two new research proposals accepted to a total value of 5.46 million ECU, subject to final approval by the European Parliament. Since the Pilot and Demonstration Programme was introduced, the value of research contracts awarded to British Steel as a proportion of the total budget, averaged over several years, has broadly matched the proportion of the levy contributions under the ECSC Treaty made by the UK steel industry.

The direct financial return to individual companies from EEC/ECSC programmes depends on their willingness to participate in the procedures that have been developed, tried and tested over many years by the Commission for selecting which research proposals should receive support. All EEC programmes are significantly over subscribed. It is the quality of the research proposals, the relevance of the proposals to the programme objectives (defined after consultation with the Governments of member states and other organisations), the level of risk (both financial and technical) in the proposal, together with the confidence of the experts advising the Commission in the expertise and facilities available in the organisations making the research proposals, that normally determines which are accepted. The funds available to assist the economically significant application of new knowledge or techniques are relatively limited. Only about 10 per cent of the annual ECSC operating budget is allocated to the Research programme, although large reserves have been built up over the duration of the Treaty. Currently the annual levy provides less than half of the operating budget with the balance coming from interest on loans, or repayments of loans made from the reserves. There have been recent suggestions that the level of support given under some programmes, such as the ECSC Pilot and Demonstration Programme, is too high and is contrary to the objectives of promoting free competition within the single market. Any significant reduction in the level of support provided would be a major deterrent to seeking aid, in view of the high risk element inherent in many of the research proposals, the number of proposals rejected, and the significant cost in applying for aid under the EEC/ECSC programmes (typically up to 5 per cent of the value of the proposals accepted).

Q9 *What are the effects of the varying relationships between companies and their suppliers?*
A. With some exceptions as to certain processes used in the steel industry, British plant suppliers in the metallurgical field are generally not innovators. At best they are traders in technology licensing, and in applying that technology they frequently require technical help and supervision from British Steel.

British Steel undertakes significant developments in-house. The application of these developments at the prototype or production scale will usually involve a plant supplier. When technology is purchased through a licensing agreement, there is considerable injection of British Steel expertise and technology in adapting the purchased technology to its own requirements. The developed technology may or may not be fully protectable and is invariably, perhaps inevitably, used by the plant supplier in subsequent contracts. This situation can lead to distrust between the developer and the plant supplier as the benefits of the steel company's own technology (developed at its own expense) become available to a competitor. Whilst it might be argued that the benefits from plant supplier/steel company collaboration are compensatory between projects, the truth is that the technology inputs of the different parties is rarely equal.

Q10 *What factors influence decisions to invest in innovation in the UK or overseas?*
A. British Steel's manufacturing base is in the UK and its R&D facilities have been rationalised on to four sites in the UK. The facilities and technical expertise of the staff are recognised throughout the world, as being amongst the best and the *pro rata* costs very competitive. Value for money is also deemed to be high. There is a history of collaborative projects with other European steelmakers being centred on British Steel Laboratories. This does not mean that all investment in innovation is in the UK. Indeed British Steel has

joint work with steel companies and research laboratories in Europe, particularly in Belgium, Holland, Italy and France and elsewhere, e.g., Korea, where use is made of specific expertise or specific facilities which are more appropriate for the innovatory step than are available in British Steel. The developed process usually has been or will eventually be translated into British Steel's operating plants.

Q11 *In the light of ACOST's report Defence R&D: A National Resource, and the Government's response, is there a satisfactory relationship between the defence and civil sectors.*
A. Item 1.7 of the ACOST report recommends that "MOD should encourage industry through its contractual arrangements to fund its own technology and product development and should be more prepared to accept that companies will expect a level of return of profitability commensurate with the technological and financial risks undertaken".

Financial support which British Steel receives from MOD for work of this type is insignificant, particularly compared with the very substantial funding which the US Defence Department (through for example, the American Navy) provides for technological development to Universities and industrial research laboratories.

Some work is funded predominantly by British Steel, and the steel developments are evaluated by MOD for defence requirements. British Steel is seeking a return from the expenditure and risks in undertaking the work by way of orders for steel. The information and steel specifications developed by British Steel are available for support of other projects or applications in the private sector.

Memorandum by Brown & Root (UK) Limited

The Brown & Root (UK) Group of Companies cover a number of service and manufacturing areas in the marine, defence, transport, nuclear and aerospace industries offering as diverse a range of services as engineering, design, procurement, construction and installation of North Sea oil and gas platforms to their subsea inspection, maintenance and repair, to naval refits, the largest civil engineering project in the world and highly specialised, multi-disciplined engineering projects. As you can imagine, this covers a multitude of markets, disciplines and areas of expertise.

Brown & Root needs to stay at the leading edge of technology across all these areas and the company's attitudes and structures reflect this. The company has, in its pioneering days in North Sea marine engineering, had to break new ground in technology and innovation almost at every turn and to this end has drawn increasingly on UK resources for its expertise—both in engineering graduates and from R&D in university departments. Brown & Root has therefore had to ensure it can attract and retain the best of British engineers and as a result their pay scales and benefits package has had to be competitive with, if not actually leading, the market.

One part of this has been Brown & Root's wish to push decision making down the line as far as possible and to ensure that project managers are truly responsible for their own projects in every way; including technical, commercial and financial, i.e., profit (!). In order to achieve this we have invested in a high level of training.

In a large engineering and design operation it is essential to have a well proven basis of systems and controls to ensure adequate checking against both standards and accuracy. This is particularly important in the area of safety where as a result of the Piper Alpha disaster the imposition of additional required standards has become necessary. It is our principle that the highest level of safety and the most innovative of designs can go hand in hand.

As a company our investment decisions have to reflect the significant application of new knowledge and techniques. As leading offshore marine engineers B&R has led development in the use of computer aided design and engineering. 2D CAD has helped cut drafting activity manhours by a factor of two and thus helped to control costs, with significant savings on larger projects. At the same time B&R is the world leader in the application of 3D CAD technology to offshore platform design. This has involved spending around £1 million on each new project in equipment and software, which has itself involved several million pounds in its development. Our current annual budget for development and support of CAD systems is well over £1 million.

An additional example of Brown & Root's diversity and investment in innovation is BRV's 100 per cent owned company Integrated Documatics Limited (IDL), which, as a consultant, specialises in the integration of PC-based imaging systems and advises on records and information management. This has involved taking a lead as the only UK-based imaging system integration team and the development of a networked PC-document imaging system. This particular development grew out of the considerable software and systems expertise which backs up the main stream design operation and was funded by the company at a time when North Sea activity fell dramatically.

The application and pursuit of innovation in the oil and gas industry in particular is, of necessity, through the hands on application of Brown & Root's engineers, backed up by appropriate research contracts with university departments and other R&D organisations. We are at all times seeking more innovative designs and methods, coupled with the necessity to reduce the high costs of offshore development and this has helped keep us at the forefront, from the very early days to the present day, e.g., in the design of tension leg platforms, floating and subsea production systems and installation methods and heavy lift transportation.

My general comments above address questions one and three of your letter and I will briefly run through some of the other points you have raised.

2. Technology is based in the UK, after initially transferring the offshore technology from Houston, USA where the Gulf of Mexico technology was developed. London is now the world leader in offshore design technology and indeed the US parent company moved the headquarters of its marine and offshore operations to London in January 1989. As one of the leaders in this particular area of technology supported by a worldwide network of operations we keep in close touch with all developments in a market which is particularly open.

4. The oil and gas industry is a very self-supporting and internationally mobile one, but there are areas where Government seeks to assist and does so—though these are not immensely significant.

5. No comment.

6. Regulation is an increasingly important factor and we play our part on both the input to Government/Regulators as well as on the implementation and monitoring sides.

7. Our experience is good where we identify an opportunity, but the question must be how many opportunities do we miss through ignorance of their existence.

8. Probably not because we object to the bureaucracy involved, although we have some EC-funded development work in progress.

9. This is an area of serious current concern. Our suppliers are failing us.

10. There are significant political and commercial considerations for each case.

11. Defence has a community of its own and as a newcomer to that community it is a salutary experience.

I apologise for my brevity in some instances but I hope that this response will prove worthwhile to your Sub-Committee's deliberations.

J R S MORRIS
Director

Memorandum by Dr D W Budworth

SHORT-TERMISM

Summary

It is suggested that no short-term solution to the problem of "short-termism" is likely to be found. What seems to be needed is the parallel development of valuation and accounting methods for intangible assets of companies, to correct the current bias in company accounting and hence management in favour of the present as opposed to the future.

Introduction

1. As an independent consultant, mainly engaged in research co-ordination, I had not orginally thought I could contribute usefully to the Committee's enquiry. The questions posed in the letter from the Clerk, of which a copy sent to me as Industry Director of the Science Policy Support Group is dated 13 February 1990, were not such that I considered that I had anything of specific value to say. Recent publicity has, however, been given to evidence on the phenomenon of "short-termism" and, since I have been attempting to develop a solution to this problem in one way or another for some years, I thought that a short contribution might be of assistance.

2. My interest in the subject was originally stimulated some twenty years ago, as a Research Manager in industry, but my attempts to find a solution date from about 1983. As the newly-appointed Deputy Director of the Technical Division of the CBI, I started to place emphasis on the total process of innovation, rather than on the research and development (R&D) aspects of it alone, and in particular to seek for ways of reconciling the technical and financial aspects of innovation. The Select Committee's Report on "Engineering Research and Development" (1), was influential in persuading the relevant CBI Committee that the subject was worthy of detailed consideration. I was fortunate to be able to study it in greater depth during a three-month tenure of the GEC Visiting Industrial Fellowship at University College, Oxford, in

the spring of 1986 and, since leaving the CBI later that year, have maintained interest and some activity in the field. Most recently, in my limited term and part-time appointment at the Science Policy Support Group, I have set up a network of people interested in the subject of intangible assets of companies.

GENERAL APPROACH TO COMBATTING "SHORT-TERMISM"

3. A good case could be made that the phenomenon of "short-termism" is endemic in British life. Whatever the truth of the matter, however, there seem to be no practical alternatives to recognising that we must start from where we are, and that changes must be gradual. It would be unwise to look for short-term solutions to a problem which is apparently so well rooted and of such long history.

4. The problem of "short-termism", as it affects innovation, manifests itself as the advantages perceived by company managements of enhancing immediate profits by minimising spending on such items as research and development (R&D) and training, which are necessary for innovation, but which would be expected to yield profits in future years, if at all. The threat of a takeover bid if profits fall is undoubtedly a real one, and even the Chairman of ICI has recently been reported as being concerned about City pressures, but the problem is not universal. A pharmaceutical company which significantly reduced its R&D expenditure would almost certainly see a drop in its share price, with consequent increased risk of takeover. Nor do institutional investors always sell out when a takeover bid is made, as was demonstrated in the cases of Pilkington and, very recently, of Molins.

5. The essential difficulty seems to be one of communication. Companies which have a well-thought-out strategy and the managerial capacity to execute it, and which convey both those facts to their investors, have less to fear from short-term pressures than companies which are deficient in one or more of these respects.

6. A fundamental and inadequately-recognised problem is that the model of company operation which implicitly underlies company law and accounting is of an organisation which makes the same product (or provides the same service) in perpetuity.(2) Expenditure on renewal of the product range, as opposed to the company's physical assets, is not recognised as the normal and essential feature which in modern conditions of competition it undoubtedly is. A company's ability to adapt to change—to innovate—is critical to its survival, and constitutes perhaps its most important, but intangible, asset.

7. The initial work at CBI was therefore devoted to developing a financial model of company operation in which innovation played an integral part. It was based on the theme that innovation expenditure should be looked upon as in many ways analogous to the depreciation provision. While the latter provides a fund for the renewal of physical assets, innovation expenditure makes good the erosion of intangible assets arising from improvement of competitors' products.

8. The model was subsequently developed, and a full account has been published.(3) Since the main aim at that time was to assist companies in communicating with their investors, the emphasis was on the presentation of innovation expenditure within the present framework of company law and accounting standards. It was suggested that this could be done through an added value statement which could appear as a supplement to the statutory published accounts.

ACCOUNTING DEVELOPMENT

9. Further development of the approach seems to require advances in two directions: modification of accounting conventions to give appropriate weight to the intangible components of a company's assets; and —as a necessary preliminary—improved measurements of expenditure on the various elements of innovation and on the returns from it.

10. At present, although companies are frequently urged to "invest" more in R&D, and less frequently in training, such expenditure is, for accounting purposes, usually treated as a current expense. While this treatment complies with the "prudence principle" of accounting, it deprives users of accounts of information which might help them to decide whether the management was maintaining the company's stock of intangible assets. Accountants are, however, understandably reluctant to capitalise items of whose value they have no reasonably reliable measurements.

11. While the technical community has been slow to face up to the challenge of demonstrating its value in financial terms, the advertising and brand management community has recently risen to it, with the result that some companies have begun to include the value of their brands as intangible assets on their balance sheets.

12. The reasons for this development are complex, and it has given rise to much controversy. It has, however, served the purpose of turning the spotlight on the purpose of accounts, the models of company operation which underlie them, and the importance of intangible assets. A recent survey of the field (4) comes down in favour of including more intangible assets, including development expenditure, in balance sheets, but suggests that there are three areas which need further work:

(i) Valuation techniques for various forms of intangible assets which are generally regarded as reliable.

(ii) Suitable non-financial indicators relating to intangible business success factors.
(iii) Financial measures related to people values.

13. Some academic and other work is already going on in these areas, involving managers with responsibility for R&D, training, brands, and new products; academic and practising accountants; economists; and students of technology policy. These diverse groups have often yet to recognise their common interests. Further and more co-ordinated work along these lines, which recognise that success in companies depends more on internal factors than on external ones, is much more likely in the long run to improve British performance than are subsidies or other short-term measures.

REFERENCES

(1) House of Lords Select Committee on Science and Technology, "Engineering Research and Development", HL89 (1983-83), published 9 March 1983.

(2) D W Budworth, "Was Adam Smith Right About Companies", unpublished paper given at Tech88 Conference, Edinburgh, 1988.

(3) D W Budworth, "Rewinding the Mainspring", Technical Change Centre, 1987.

(4) Coopers and Lybrand Deloitte, "Intangible Assets: Their Value and How to Report It", 1990.

Dr D W BUDWORTH
4 *June* 1990

Memorandum from Sir Charles Carter

This note summarises some conclusions reached in observations over forty years. It concludes:

(a) Innovation should be considered in the wider context of the exploitation of new ideas, whatever the place of their original development.
(b) Government policies to spread knowledge and encourage innovation, though not ineffective (as the record in microelectronics shows), may have disappointing results unless there is an improvement in the general quality of manufacturing management.
(c) We need a study of the reasons for the relative unattractiveness of manufacturing to people of high ability: a review of the quality and rigour of management education: and a consideration of whether Government is doing all in its power to stabilise the environment of manufacturing and thus allow the long-term thinking essential to effective innovation and technical progress.

1. I am an economist specialising in industrial economics. This note is based on observation of the process of innovation over a long period, commencing with the work led by myself and Sir Bruce Williams in the 1950's (see *Industry and Technical Progress* (1957), *Investment in Innovation* (1958), *Science in Industry* (1959), all published by the Oxford University Press). I have reverted to the subject of that early work on a number of occasions (see, in particular, *Industry and Technical Progress* in Leontief: *Structure, System and Economic Policy*, Cambridge University Press, 1977). I have been associated with the extensive programme of study of microelectronics and robotics, undertaken in recent years at the Policy Studies Institute; and I have had other opportunities to observe the process and problems of innovation in a variety of firms.

2. In the 1957 book we defined *invention* as the creation and development of a new idea, whereas *innovation* is the act of bringing it into practical use: this appears to be close to the definition used by your Sub-Committee. Our focus of interest was however the *technically progressive firm*, defined to be one which is keeping within reasonable distance of the best current practice in the application of science and technology. Such firms often engage in innovation, but some will be classed as technically progressive because they have made skilful use of ideas brought to the point of practical application elsewhere. There should be no suggestion that this use of other men's brains is an inferior activity. The 1977 paper comments, under the heading *insularity*—

> "Too much effort is used in reinventing things, or in producing private British systems which are no better than those being developed in other countries (and are probably designed in a way which makes them unsuitable for export). It should be remembered that the *essential* part of a country's research and development is the ability to keep in touch with and understand the discoveries being made in the rest of the world, and to adapt them to local circumstances. One could have a highly successful economy without having any significant discoveries of one's own; this is indeed obvious, for small countries cannot possibly afford to be active in more than a tiny part of the possible areas of research and development, amd must necessarily depend on the international flow of ideas and licensed knowledge. Instead of pretending that we are self-sufficient, we would do well to concentrate research, development and design in areas which are given insufficient attention in all countries, in those in which there are impediments to the international flow, and in a few in which we can build on acknowledged success."

3. I would therefore urge the Sub-Committee to look, not only at innovation, but at the intelligent adaptation of other people's innovations. The argument above for the concentration of innovation has

become stronger, since Britain has indeed become a small country when measured by its share of world output. But it requires one gloss. A small country needs "listening posts" to enable it to understand what is offered by the world flow of developed ideas. Some of these ideas will flow in readily, perhaps promoted by the sellers of equipment; but in particular areas of science the flow can only take place between high-level specialists, and those who man the listening posts are likely to be the kind of people who will be interested in innovation of their own. So in some areas a spread of innovatory activity may be the condition for keeping up with the rest of the world.

4. In the 1957 book we asserted that:

> "Technical progressiveness is related to the general quality of the firm; and attention to other aspects of its general quality—for instance, to management efficiency and market research—helps to create the conditions for technical progress. In other words, the use of science is not an optional extra to be attached to the firm, but an expression of the whole attitude of the firm."

This conclusion is strongly supported by observation over the past 30 years (and it applies to that aspect of technical progressiveness which results in innovation): but the implications for policy have never been sufficiently understood. Measures designed to spread knowledge or to assist or induce innovation will have only limited success if other aspects of quality are missing. Measures not specifically related to innovation, for instance to educate managers in rigorous analysis of their problems, may turn out to be an essential precondition for successful innovation. A key issue in all this is the distribution within the whole economy of a scarce resource, namely exceptional ability; and it is not enough to increase the availability of scientific and technological ability. The opposite to the technically progressive firm is the backward firm (or public institution, or Government department): we commented in the 1957 book as follows:

> ". . . the backward firm, even if it can be made to desire technical progress, is ill placed to command the resources (and in particular the human ability) necessary to begin that progress. It will take much ingenuity by industry and government to break up the crust of habit and to divert lively and able minds from the places where change is most likely to those where it is most needed."

5. The aspects of general quality which are important include:

(a) A readiness to look outside the firm: a deliberate survey of potential ideas; a willingness to take new knowledge on licence and to enter joint ventures.
(b) Effective internal communication and co-ordination.
(c) Good cost accountancy, including an understanding of costs and profits in the research and development departments (if any).
(d) Sound and rigorous analysis of investment decisions.
(e) Intelligent use of modern management techniques.
(f) Good recruitment and training policies.
(g) High quality in the chief executive (or other identifiable "leader").
(h) Good quality in intermediate management (and an ability to bring the best out of managers).
(i) Willingness to plan over a fairly long period.
(j) Effective understanding of markets, and good service to customers.
(k) Readiness to scrap outdated plant.
(l) Leadership which gives a high status to science and technology (though this does not imply that the top people must themselves be scientists or technologists).

6. High performance in all these areas is found only in a few places; but it is essential to successful innovation that the performance should at least be adequate. Members of the Sub-Committee will readily call to mind examples of innovations which have failed because the understanding of market needs was inadequate, or because too little attention was paid to experience overseas, or for some other reason not directly concerned with the quality of scientific input.

7. It is evident that the key to "good overall quality" lies in the general quality of management: and that in turn suggests that we should consider:

(a) The distribution of high ability between occupations, and the obstacles to using it to the full (for instance, the residual bias against women executives). At present the service trades, and in particular financial services, are much more likely to attract able people than the less glamorous parts of manufacturing industry. This is not entirely to be condemned: a small country must specialise, and Britain has specialised with great success in financial services. But the diversion of ability has gone dangerously far: we need, not only to avoid further erosion of the manufacturing base, but to increase our ability to produce an advanced manufacturing output. In considering the supply of ability, it is also a matter of concern that the school teaching profession is unattractive to able people.
(b) The quality of management education. The availability of management education and training has improved in the last twenty years, and we should see advantages from this as those who have been through it reach senior positions. But I would express a personal view, based on an observation of failures of management, that there is far to much sloppy thinking in British industry and commerce. Senior executives imagine that a hunch can take the place of careful and rigorous analysis, including a disciplined judgment of uncertainty. I am far from convinced that our management education sets high enough standards of rigour and discipline (in comparison,

for instance, with the *hautes ecoles* in France). It is also a matter of concern that management education has to build on a school system which is lacking in the encouragement of rigorous thinking.

(c) Obstacles to the effective use of management time. These include, for instance, the diversion of effort to the more sterile minutiae of labour relations, or to tax evasion. But a major problem is the propensity of governments—even those which profess to want to reduce burdens on business—to create uncertainty and extra work by frequent initiatives or changes of policy. A stable environment, free of stop-start policies, changes in the regulatory system, and great fluctuations in interest rates or exchange rates, allows management the opportunity for long-term thinking which can lead to wise innovation. Total stability is of course neither possible—for international forces require change—nor desirable; but I believe it would be favourable to innovation if Governments could curb their propensity to meddle.

8. My comments on the Sub-Committee's remit are therefore:

(a) Innovation should be considered in the wider context of the exploitation of new ideas, whatever the place of their original development.

(b) Government policies to spread knowledge and encourage innovation, though not ineffective (as the record in microelectronics shows), may have disappointing results unless there is an improvement in the general quality of manufacturing management.

(c) We need a study of the reasons for the relative unattractiveness of manufacturing to people of high ability: a review of the quality and rigour of management education: and a consideration of whether Government is doing all in its power to stabilise the environment of manufacturing and thus allow the long-term thinking essential to effective innovation and technical progress.

April 1990

Memorandum by the Centre for Exploitation of Science and Technology

1 Sources

The comments are drawn largely from the following sources.

1.1 Projects undertaken or on going at CEST in the fields of demography and healthcare, materials, information and the environment.

1.2 Four surveys undertaken by CEST in 1989 and reported in the following documents.

1.2 (a) Attitudes to the exploitation of science and technology (1990).

1.2 (b) Scientists views of the exploitation of science and technology (1990) (to be published).

1.2 (c) Information flows into industrial research (1989)

1.2 (d) A new indicator of scientific research in industry (1990).

1.3 CEST Member companies, some of whom will have submitted evidence to the Committee directly.

In particular 1.2 (a) and (b) covered many of the points raised in the questions (30 January 1990).

Q1 *What are the effects of company attitudes and structures?*

Company attitudes to innovation are very important. In the survey, "Attitudes to the Exploitation . . .", industrialists volunteer organisational factors as a constraint. Two factors are seen as being particularly important namely the need for more creative organisations and the avoidance of excessive conservatism. They note that changes in company culture are difficult and only achieved over a long term. Practical strategies to achieve change include: biased recruitment, devolving responsibility, exposing managers in new venture units or small companies, allowing researchers unbudgetted time and encouraging constructive user/peer group discussions.

The study, "Information flows . . .", alerts companies to the fact that many researchers are not sufficiently orientated to the firm's external environment as shown by patterns of researcher communication. Encouragement of studies of competitors' technology, etc., probably represents best practice.

Overall these sum up to the necessity for companies to have the confidence to commit to innovation.

Q2 *How active are UK companies in seeking out external technology, especially from overseas? How well do they adapt and apply it?*

The most important source of technology is in-house R&D. However, the studies show that there is a considerable change occurring in the pattern of technology sourcing. This includes external collaboration with domestic and foreign companies and universities, through licensing, joint venture, mergers and acquisitions, etc. Companies are becoming able to identify which technologies must be developed in-house and which can be sourced externally. The study, "Attitudes . . . ", highlighted a mixed set of opinions as to the efficacy of corporate R&D functions because of the great need, but real difficulty, to match technology developments, either internally or externally generated, to the needs of the business. In multi-divisional companies, research in subsidiaries is seen as being of increasing significance. EEC programmes are frequently mentioned as sources of technology provided that the necessary management commitment can be made. They can represent good value.

Some university scientists observe that UK companies are slow relative to the Japanese, US and Germans in seeing the value of scientific work.

Most industries see a growth in collaboration as being a way of leveraging the R&D spend. The competitive gain which can be achieved therefore depends on how effectively it manages its collaborations and the sources of external technology. The problem lies in avoiding the "levelling down" effect of collaboration with weaker companies or university groups. The management of collaboration itself now emerges as a key competitive factor that is the configurations which it is possible for a company to assemble could enable much more rapid innovation to take place. Hence the emergence of project management as a key skill and even as a contracted service carried out by specialist companies for international consortia, particularly in the aerospace field.

Q3 *What are the respective roles played by product development and production engineering in technological innovation?*
Distinction between these two activities as an input to policy analyses could be very unhelpful.

The ability to compete strongly is directly correlated with the ability to exploit faster than competitors. This is not to be interpreted that the first to market is likely to be the most successful but that speed gives companies the opportunity to change faster or more frequently and therefore reduces risk.

The distinction between product development and production engineering is therefore becoming blurred with these activities being undertaken in parallel. This has come to be called parallel engineering. The current view, "Attitudes to Exploitation . . . ", is that the best UK companies can exploit technology as fast as the USA but that the Japanese are noticeably faster.

In addition specific action is being taken to accelerate R&D. These include:
- Better tools.
- Modelling as opposed to experimental work.
- Better processes.
- CAD/CAM to reduce design to production.
- Improved research management.

Companies are spending more time communicating a clear view of the basis of competitive position and the R&D implications, throughout their research and engineering functions.

Q4 *How effective are the activities of Government Departments in promoting and supporting innovation?*
In as far that Government is emphasising collaboration this should improve exploitation but collaboration itself is not the overall objective.

This means that the collaborating companies and academics should be chosen on their combined ability to deliver fast exploitation. This is not normally a criterion applied by Government scheme administrators.

The form of the collaborative groups assembled by Government and EEC are horizontal pre-competitive. Innovation requires vertical collaboration, i.e., supplier-customer relationships to be established. This is likely to involve both large and small companies. There are therefore dangers in forcing "collaboration" as a criterion for accepting grant applications, e.g., small companies find collaboration hard to establish especially in the case of EEC schemes which require international collaboration.

Academics views, "Scientists views . . . ", of the exploitation environment as conditioned by government cited stability and continuity in funding policies as helpful. Some CEST companies feel that the Government does have a role in establishing capability in some of the generic technologies.

Q5 *What are the effects of City attitudes to investment in innovation?*
No new comments.

Q6 *What is the effect of legislative and regulatory framework concerning for example labour costs, patent laws and tax concessions on R&D and the purchase of know-how?*
Exploitation is affected by a wide range of regulatory or legislative factors. CEST has been concerned that in its projects these factors are also considered when analysing the opportunities in emergent markets. For example the lack of internationally agreed standards in the field of adhesive bonding was considered as well as fundamental science issues such as surface chemistry or technologies such as NDT. Since the form of the agreed standards will directly affect the course of the R&D necessary to produce testing methods.

Legislation can stimulate innovation, for example environmental concerns. Nevertheless, one implication could be that the process of making legislation should be transparent and interactive to minimise uncertainty and to maximise the chance of enhancing the position of UK industry with respect to its competition, for environmental issues this means managing Brussels as well.

Industry still questions whether incentive should be given to R&D through tax incentives. However, the common view is that a favourable economic climate in which to do business would be as effective.

Q7 *How effective are the mechanisms for technology transfer from HEIs, Research Councils and public laboratories to manufacturing industry?*
UK industry makes considerable use of HEIs as a technological source, 70 per cent used HEIs, 40 per cent non-UK HEIs ("Attitudes . . ."). Users highlighted the following, project timescales are difficult to control, HEIs can be good value for money especially on closely defined projects, but the relationship has to be managed.

However universities claim that they are able to spot exploitable opportunities, ("Scientists views . . ."). However it is more plausible to suppose that universities can identify potential applications, without understanding the problems of successful exploitation, which can only be derived from a detailed understanding of particular markets and the business environment. There seems to be considerable scope for improving the interface.

If potential collaborators can agree areas of common interest then progress can be made in improving the communication of results. In short a "team" relationship has to established between the companies and appropriate HEIs. An example as to how this might be achieved is the CEST methodology since this allows new collaboration to be developed around an issues driven perspective.

Q8 *Does the UK benefit sufficiently from EEC support for innovation? How might it be improved?*
In as far as EEC programs allow companies to leverage their R&D spend then they should represent good value. However the realisation of this potential depends on subsequent exploitation of the results by UK companies.

The evidence suggests that UK academics have been very effective in joining EEC-funded collaborative research programs, to the benefit of non-UK companies. Examples identified by CEST include the work on micro-machines and telemedicine at the University of Edinburgh. UK companies need assistance in locating university centres of excellence outside the EEC to enter future collaboration and within the UK to avoid having to sell (i.e., under-sell) their experience overseas.

Companies comment on the complexity of the bureaucracy but feel that such EEC support is positive but time consuming.

Q9 *What are the effects of varying relationships between companies and their suppliers?*
In manufacturing industries customers are seen as the dominant source of triggers of innovation. Suppliers are only seen as the source of triggers in non-manufacturing industries. However both domestic and foreign suppliers are seen as sources of technology, ("Attitudes . . .").

For these reasons any efforts to improve exploitation performance must consider the effect on the vertical supplier-customer chains when seeking to maximise value. Most collaboration organised by governments and the EEC emphasises horizontal pre-competitive chains.

10 *What factors influence decisions to invest in innovation in the UK or overseas? This question is ambiguous. The questioner wishes to investigate the factors which influence choice of location.*
Companies will be basing their location choices on the factors which influence innovative success, i.e.,
Opportunity.
Timing.
Technology.
Financing and resourcing.
Management.
People.
Marketing.

The order of this list will depend on the company. In the case of inward investment, attention could be given to quality and availability of people, UK academic reputation, educational systems, 1992 and access to European market. The ability of UK authorities to respond quickly and flexibly would also appear to assist.

Also we need to offer a low uncertainty business environment, where of the five key constituencies (producers, investors, workers, consumers, regulators), it is the former which are seen to dominate (in defining the "rules of the game").

11 *In the light of ACOSTs report Defence R&D: A national resource and the Government's response, is there a satisfactory relationship between the defence and the civil sectors?*
Companies reaction to this question is mixed, some feeling that progress is being made, others that progress is slow. Some concern has been expressed the MOD does not recognise that it has a role to use its R&D procedures to stimulate both defence and civil sectors, one of the recommendations of the ACOST. MOD does not accept the "dual use", (civil and military), of much science and technology.

28 *March* 1990

Memorandum by the Chemical Industries Association Limited

Thank you for inviting the Chemical Industries Association to submit evidence to this enquiry.

We have decided to be selective in our response by focusing on certain key points for the chemical industry, rather than commenting upon all of your questions.

The chemical industry, at the forefront of modern technology, is a prime wealth-creating sector of the economy. Almost every other industry and activity depends in some measure upon its products. It generates a positive trade surplus of about £2 billion annually. Investment in R&D by the UK chemical industry has grown very vigorously in recent years and in 1988 (the most recent figures available) reached £1,570 million, accounting for almost 6 per cent of the industry's sales turnover. The industry's reliance on government financial support for its R&D efforts, in contrast to many other industries, is very low. The capital investment programme for the next two years, again in contrast with the rest of manufacturing, shows a continuation of the recent rising trend.

The setting up of your enquiry, and the tone of some of the questions, implies a lack of innovation in manufacturing industry generally. However, against the background set out above, the issue in the chemical industry is more one of maintaining its successful position and its record of innovation.

THE ROLE OF GOVERNMENT DEPARTMENTS AND AGENCIES (QUESTIONS 4 AND 7)

The chemical industry's strength has been, and will remain, closely dependent upon a high-quality science base. The flow of ideas and discoveries from fundamental academic research provides the seed-corn for industrial research and innovation; and—at least as important—the education system plays a vital role in the provision of intelligent, trained and enquiring graduates in science and technology for the industry. Maintenance and improvement of this science base—including the provision of highly-qualified manpower—is, in our view, the single most important role for Government in its support of industrial innovation in the longer term.

There has recently been a deliberate focusing by Government, in its funding programmes, upon strategic research. This concept has been supported by the chemical industry and indeed we produced a report "Priority Areas for Chemicals R&D" as a contribution to this thinking. Much of the work of relevant SERC Committees has provided a valuable, strategic focus. The recent establishment of Interdisciplinary Research Centres provides a useful mechanism for establishing research activities with a critical mass and able to cross traditional disciplinary boundaries—although, once established, they should not be allowed to become set in concrete. However, whilst supporting these concepts, we believe there is a real danger that the current pre-occupation with "exploitability" of research may be overdone, and that in the long-term industry as well as the universities may be disadvantaged by this. Basic research, which chemical companies look to the academic sector to provide, must not be squeezed out by a shift towards applicability which itself is dictated by a drive towards obtaining industrial funding.

The modest amounts of DTI funding used to support chemical industry R&D can provide a valuable catalyst, for medium-sized and smaller companies as well as for the larger firms. Speed of response by the Department in handling applications varies from the quick to the frustrating. There are also instances of useful collaboration with the Ministry of Defence.

THE LEGISLATIVE AND REGULATORY FRAMEWORK (QUESTION 6)

Of the examples cited in the question, we particularly wish to draw attention to the need for intellectual property rights to be strengthened, in support of innovation. We strongly support the European Commission's recent draft regulation on the restoration of the effective patent term to allow for the time consumed in authorisation procedures, and would like to see this extended as soon as practicable to cover other product areas (e.g., agrochemicals) as well as pharmaceuticals; equally we believe that the patentability of biotechnological inventions is of major importance to companies engaged in R&D in this field; and we support the strengthening of intellectual property rights internationally via the GATT.

Delays in official testing and registration of new products in the UK area are a major source of concern in some parts of the chemical industry. This problem applies particularly to approvals for new agrochemical products.

There are other aspects of the legislative and regulatory framework that have an effect on chemicals R&D. These include:

(i) *Statutory requirements to disclose information*
A pertinent example is The Environmental Protection Bill, Part I, Clause 18—Registers of Information.

If innovation in the UK is not to be jeopardised, industry will need further clarity and certainty in the following areas:

- The definition of what monitoring and compliance information is to appear in public registers, e.g., will this include process information such as catalyst, operating conditions, which would be of considerable value to competitors?
- Ground rules for the circumstances in which the test of prejudicing "to an unreasonable degree some person's commercial interest" would or would not be satisfied.
- The mechanism for reaching a decision on that test.

As things currently stand, there is a distinct danger that the UK will progress much further down the route to disclosure of information to the public than is the case in either the USA or Japan. Were this to happen there could be an adverse effect on R&D and innovation in the UK. (See also our comments under Question 10).

(ii) *Biotechnology and genetically-modified organisms*

Modern biotechnology based on genetically-modified organisms (GMOs) is a key area of research and innovation for several industrial sectors including chemicals, pharmaceuticals, pesticides, foods and seeds. However, Part VI of the Environmental Protection Bill adopts an extremely negative tone which seems to be based on the premise that GMOs are *per se* harmful to man and the environment. Were this approach to be carried through into regulations, there is a real danger that:

- The competitiveness of the UK as a centre of excellence for biotechnology will be destroyed.
- The population of the UK will be denied access to better health care and agricultural products which are more freely available in other parts of the world.

(iii) *Notification and marketing of new substances*

The key to the continued viability and success of the chemical industry is the ability to innovate and market new products. It is therefore vital that current EEC negotiations on a proposal to amend for the seventh time Directive 67/548/EEC (implemented in the UK by the Notification of New Substances Regulations 1982) maintain the competitive position of the European Chemical Industry *vis-a-vis* our major trading partners, e.g., USA and Japan. CIA is liaising closely with UK Government (HSE) and, via CEFIC (Conseil Européen des Fédérations de L'Industrie Chimique), with the European Commission to this end. (See also Proceedings of the CEFIC Workshop on Innovation and the Seventh Amendment) [*Not printed*].

EC SUPPORT FOR INNOVATION (QUESTION 8)

Collaborative research, as encouraged by the EC programmes, can be a valuable activity, but the availability of EC funding (or DTI funding in the case of UK programmes) should not be the main reason for pursuing such research: the activity needs to be valid in its own right as part of the company's business strategy, e.g., for collaboration with key customers in developing technology.

A feature of EC support programmes which should be encouraged is the opportunity that they provide for industry to work together in non-competitive areas such as the development of improved toxicological testing and fire standards.

Procedures for obtaining EC financial support tend to be time-consuming and this deters many companies. Negotiation of intellectual property rights with the collaborative partners can cause difficulties if not done at an early stage. One disturbing feature of EC support programmes which one of our member companies has commented upon is the lack of security of information: there have been some bad experiences of leaks of information to competitors.

LOCATION OF INNOVATIVE EFFORT (QUESTION 10)

The basic factors affecting location are business strategy, the requirements of the market, the availability of science, technology and qualified staff, and the relative costs involved.

One specific factor which influences decisions about where to invest in innovation is the extent to which the regulatory framework in the country in question provides any degree of certainty about requirements that will have to be fulfilled.

For example, uncertainties and ambiguities in current German legislation governing biotechnology (see also our comments under Question 6) have caused certain German companies to decide to invest in biotechnological research outside Germany.

For the reasons already mentioned and the additional reason that current draft UK legislation makes no provision for appeal against refusal of an authorisation or against the conditions of an authorisation, UK companies may well look seriously at removing this aspect of R&D to either the USA or Japan.

ACOST (QUESTION 11)

We believe that ACOST is performing a valuable role. We recognise the confidential nature of much of its work but we would urge Government to see whether industry can be given greater and speedier access to the results of relevant enquiries by ACOST.

THE IMPORTANCE OF INFORMATION TECHNOLOGY

Although Information Technology (IT) was not specifically mentioned in your list of questions, we believe that its importance in relation to innovation should be noted by the Committee.

Information Technology will play an increasingly-important role as one of the key enablers of innovation, as advances in IT offer more powerful techniques and a reduction in the real costs of applying them.

In recognition of the more demanding requirements in the marketplace for product quality, consistency of performance and quick delivery, global communication networks are being established to provide closer and quicker interactions between suppliers and users. Such data exchange allows the supplier to understand better the market needs, to monitor product performance in use, and to improve the design and operation of the manufacturing process.

For a chemically-based product that provides special effects in use, a key issue is the rational design of the product to obtain the desired results without unwanted side effects. The use of computer modelling in combination with large commercial and technical databases allows the design of laboratory experimentation to be focused more rapidly on promising options, thus raising the creativity of the research process and the effectiveness of the innovation process.

Concern for the environment and requirements for safe and more reliable processes are potent driving forces for improved process design and control. Developments in important enabling technologies include computer-aided design and engineering and the mathematical modelling of all aspects of plant design and operation, new types of sensors and measurement that allow rapid generation and handling of data, the increased use of robots and automation, and the use of expert systems to encapsulate and apply best practice.

I hope that the Committee will find the above points of interest. The Association would be pleased to provide further information if requested.

T D CULPIN
Director
24 *April* 1990

Memorandum by the Committee of Directors of Polytechnics

The Committee of Directors of Polytechnics (CDP) welcomes this opportunity to submit evidence to the House of Lords Select Committee on Science and Technology. The polytechnics and Scottish centrally funded institutions' role in developing links with industry through sandwich and other courses, together with their activities in the specialised fields of applied research and consultancy provide the background to this response.

The CDP's response to the points raised in the invitation to provide evidence focuses on numbers 4, 6, 7, 8 and 11 (although opinions on aspects of the remaining questions are also included).

Q1 *What are the effects of company attitudes and structures (including personnel policies, investment decisions)?*
Company structures are not perceived as conducive to innovation. Rigid hierarchies operate against the flow of ideas through a company and innovators may experience difficulty in establishing themselves in the management structure. Few companies maintain an R&D department, and those which do are likely to trim it first if financial problems arise; such insecurity may inhibit innovation. As a result an integrated systems approach to problem solving is likely to be abandoned in favour of "fire-fighting" techniques. The point was made to us that the valid option of subcontracting R&D to HEIs (Higher Education Institutions) was rarely adopted, although a rolling R&D programme might suit both industry and academics.

Q2 *How active are UK companies in seeking out external technology, especially from overseas? How well do they adapt and apply it?*
The "most advanced" UK companies are thought to be active in this field, but general impressions are of an unwillingness to develop new ideas or adopt new technology. Those firms which attempt to be active may find themselves unable to apply such technology if they cannot demonstrate a return on the capital invested. Many companies appear reactive rather than proactive, only seeking out external technology when forced to do so by competitors' activities or market trends.

Q3 *What are the respective roles played by product development and production engineering in technological innovation?*

The CDP regards the two activities as interdependent but notes that both operate as part of a general strategy of reducing manufacturing cost and increasing productivity levels. From experience modern engineering techniques force simplification, which requires innovative thinking and results in benefits to the companies concerned. Larger companies in particular recognise the importance of pursuing product development, although the character of both the company and its product(s) affects such decisions.

Q4 *How effective are the activities of Government departments in promoting and supporting innovation?*
The wide range of Government schemes intended directly or indirectly to promote/support innovation lack co-ordination, flexibility and self-promotion. Similar schemes sponsored by different Government departments have the potential to confuse both HEIs and industry. The CDP's experience shows that direct support from a funding body has proved more effective than via a Government intermediary where bureaucratic demands can cause some delay. However we welcome the DTI's current promotion (partly through the EITB) of new production engineering techniques and hope that the DTI/SERC Information Technology Advisory Board's Education and Training Committee will play a major role in co-ordinating future initiatives. Some of the best quality technology transfer to manufacturing industry occurs through the SERC/DTI ACME (Application of Computers to Manufacturing Engineering) directorate. The Training Agency's Enterprise in Higher Education scheme provides grants to encourage HEIs in conjunction with potential employers to provide courses in enterprise, but further national investment in training is required to encourage innovation.

Q5 *What are the effects of City attitudes on investment in innovation?*
We consider that the effect on innovation could be profound were the City's attitude to such investment more positive. Longer term investment is required and could be profitable, but some City institutions appear to focus exclusively on short-term gain; they are not natural partners for research activities which may be open-ended.

Q6 *What is the effect of the legislative and regulatory framework concerning for example labour costs, patent laws and tax concessions on R&D and the purchase of know-how?*
The current legislative and regulatory framework does not handicap the pursuit of R&D and may even in some cases stimulate innovation. However, in some fields the extensive testing required before a new product launch means that the current protection afforded by patent law is seen as insufficient to encourage innovation. Tax concessions may only enable rather than encourage innovation to occur, and are often only exploited by large firms with a sufficiently large profit base from existing products to make R&D worthwhile.

Q7 *How effective are the mechanisms for technology transfer from HEIs, Research Councils and public laboratories to manufacturing industry?*
By Spring 1990, 31 polytechnics and Scottish Central Institutions were involved in 102 Teaching Company Scheme programmes (41.8 per cent of the total). This scheme has proved successful, but would benefit from expansion to involve a greater number of major companies. A longer-term focus could also maximise the existing mutual benefits of the scheme. The British Technology Group has become more effective in recent years with better promotion of its activities, but its procedures are still considered time-consuming. Research units with direct industrial links and science and technology parks are regarded as effective transfer mechanisms, as is the SERC/DTI ACME directorate, where input is received from industry and funding bodies throughout the life of the project. The formal and informal personal contacts developed through these schemes have proved particularly effective. It is often not clear where the responsibility should lie in transferring research discoveries to the commercial sector, so increased personal contacts can offer greater opportunities for such transfers. We believe that the partial success of such transfer mechanisms may be threatened by resource reductions in PCFC institutions.

Q8 *Does the UK benefit sufficiently from EC support for innovation? How might it be improved?*
EC regional economic policy initiatives are of some benefit to the UK although polytechnics' participation has been limited. While lengthy EC procedures may be unattractive, HEIs might benefit from increased marketing of what support exists. The CDP, in association with Charles Leonard of Coventry Polytechnic, publishes an EC Information Service bi-monthly by subscription to alert subscribers (including industry and universities) to EC initiatives.

Q9 *What are the effects of the varying relationships between companies and their suppliers?*
This falls outside our remit and areas of concern.

Q10 *What factors influence decisions to invest in innovation in the UK or overseas?*
This also falls outside our remit.

Q11 *In the light of ACOST's report "Defence R&D: A National Resource", and the Government's response, is there a satisfactory relationship between the defence and civil sectors?*
The 1989 Annual Review of Government-funded R&D showed a steady decline in real terms of Government support of civil R&D. We consider that apart from companies active in both sectors, there is little cross-fertilisation and some inertia in developing commercial applications.

24 *April* 1990

Memorandum by the Committee of Vice-Chancellors and Principals

INTRODUCTION

1. Universities have been able to offer evidence on the first 8 of the 11 questions to which the Sub-committee drew attention in their invitation of written evidence related to the Sub-committee's terms of reference. This minute follows the order of the Sub-committee's questions.

GENERAL

2. Universities are active in transferring technology to manufacturing industry, not least through the supply of qualified personnel. They support efforts to encourage more co-operation at the research end of the spectrum of innovation and to help smaller companies. They are aware that problems still need to be overcome in relation to the provision of funding for new ideas and for industrial liaison activities in HEIs; in national attitudes towards appropriate training for the needs of industry; and in industrial attitudes towards research in HEIs. The comparatively poor status of engineers and scientists in many industries inhibits innovation: where, as in the fine chemicals and pharmaceuticals industries status and pay are comparatively good, innovation is also vigorous.

QUESTIONS 1-5: THE EFFECTS OF CITY AND COMPANY ATTITUDES AND STRUCTURES AND OF THE ACTIVITIES OF GOVERNMENT DEPARTMENTS

3. Innovation is an evolutionary process which draws on accumulated scholarship and experience and can include the novel application of old knowledge. Rewards to investment tend to be long-term.

4. Universities have made the following points:

(a) In some industries, such as information technology, users may be better placed than manufacturers to respond with development capital to a university group able to demonstrate potential gains, from novel hardware or software for example.

(b) Personal contact between the staffs of universities and companies, often developed over a period, is the most effective means of transferring technology. Careful targetting of suitable companies is essential. It is helpful to have information for this purpose from the disclosure of R&D expenditure in company accounts and from the recently introduced CBI Innovation Trends Survey.

(c) Small-and medium-size companies often lack trained staff able to cope with process innovations such as Computer Integrated Manufacture or computer-aided design or manufacture, but can profitably use university facilities. It is not always easy for such companies to make resources available to interact with universities. Conversely it can be difficult for universities to identify which of the many smaller companies in manufacturing might be responsive.

(d) Overseas companies—especially in the US, the EC and Japan—appear to be more active in seeking transfers from UK universities than British companies; the latter seem to prefer to develop technology in-house to a greater extent than their foreign competitors.

(e) Process innovation may be particularly fostered through "Teaching Company" schemes.

(f) Government Departments' schemes can be valuable, and particular mention has been made of the DTI's provision of information on European Community R&D programmes, and its welcome shift to a less "near-market" emphasis; however, frequent changes in policy and personnel militate against familiarity to industry which is essential if schemes are to be effective.

(g) The Government's LINK programme is compared unfavourably with ALVEY: the rules are applied comparatively inflexibly, and companies appear, from the statistics of the JFIT grant/committees, to be losing interest.

(h) It is difficult to obtain "seed-corn" finance for ideas. Venture capital is readily available only for sums in excess of about £50,000 and demands very high returns. One university has established its own fund to take projects forward to the "demonstrator" stage. Its experience is that industry collaborates much more readily in projects in which Government funding covers the research risks.

Q6. *The legislative and regulatory framework*

5. The transfer of technology from universities to industry is inhibited by too shortsighted and narrow a view of intellectual property rights. By its nature, innovation flows from a long-term, evolutionary process in which individual, focused pieces of research depend upon a long history of intellectual effort. Companies should not expect to acquire rights to the entire intellectual property underlying a specific research or innovation project in return only for the cost of the project itself.

6. There is some evidence of a shift in UK companies away from investment in R&D risks, with the consequence that it is becoming more difficult to maintain the long-term research-based relationships on which future innovation in British companies depends. Consideration should be given to tax incentives for *research* activity in companies.

Q7. *Mechanisms for technology transfer*

7. Universities have at their disposal a considerable range of mechanisms for technology transfer. They include:

- The Teaching Company Scheme;
- Specialised units providing services direct to industry;
- Industrial liaison offices offering a single first point of contact and advice and appropriate referrals;
- Innovation centres;
- Science and technology parks;
- Interdisciplinary research centres;
- CASE studentships;
- Bilateral arrangements with industry (including sponsorships, staff transfers and secondments);
- Specialist courses on new technology (including bespoke and updating courses);
- Contract research and development;
- Collaborative research and development;
- Innovation clubs;
- Consultancy;
- Licensing agreements;
- New companies set up to exploit innovations produced internally;
- SERC "Integrated Graduate Development" programmes.

8. The British Technology Group (BTG), Defence Technology Industries and Research Exploration Limited have all proved helpful, although BTG's procedures are found to be cumbersome by some universities. Some believe that regional technology centres can help small-and medium-size enterprises.

9. Universities make a major contribution to the transfer of technology and to innovation through the graduates who enter manufacturing industry. The attached tables show that higher education institutions are estimated to have produced 162,000 graduates in 1989, of whom some 41,900 received higher degrees. Engineering, technology, science, administration, business and social studies, architecture and other professions accounted for 76,100 of all graduates. A Department of Education and Science survey of all graduates produced by higher education institutions in 1980 (Employment Gazette, September 1988) showed that only 2 per cent were unemployed some six and a half years later. The 1989 study by the Institute of Manpower Studies "How many graduates in the 21st Century?" notes that numbers graduating since 1980 have grown fastest in science and engineering. A detailed breakdown of the output of graduates in engineering and technology, science and administration, business and social studies, from 1983 to 1988, and predictions for 1989, 1990 and 1991 has been published ("The Supply of University Graduates 1989-1991-Trends and Predictions": Central Services Unit for University, Polytechnic and College Careers and Appointments Services). These predictions show continuing overall growth, and, within engineering and technology, a shift towards production engineering and other technological subjects, often in combinations.

QUESTION 8: EC SUPPORT

10. Responses from universities indicate an awareness of the significant size of EC research funding. The "Framework" programme is for example worth about £3,500 million pounds over the next four years. Those universities which have experience of obtaining significant EC funding stress that UK universities and companies need to be sure to involve themselves in the planning and pre-selection phases of EC programmes. Problems particularly over the ownership of intellectual property rights can be eased at this stage. It is noted that:

- British companies with EC liaison offices tend to be rather better at evaluating EC legislation than at monitoring calls for tenders for research programmes:
- With the exception of UK multi-national companies, British companies seem to do less well in obtaining EC funding than higher education institutions:
- UK higher education institutions may be transferring technology significantly to non-UK companies (universities report difficulty in obtaining continental partners for EC programmes and suggest that DTI might provide assistance in linking higher education institutions with continental industry):
- Special project innovation finance might be helpful for regions in which it is particularly difficult to find mainland European partners:
- EC funding tends to be for large projects and is time consuming and expensive to obtain:
- Breakthroughs in innovation tend to be made in small research groups:
- The incidence of innovation across Europe with particular reference to the size of the group in which the innovation arises merits study:
- There is no standardisation of costing mechanisms among EC Directorates General:
- Such costing mechanisms as are normally used are often difficult to apply in university situations:
- Particular welcome has been given to the role of the ERDF in funding innovation centres and to the Feasibility Awards Scheme for small and medium sized enterprises.

CONCLUSION

11. Evidence from universities emphasises that although they have long experience of working with industry, structural arrangements for supporting innovation are changing rapidly. For example, one University Innovation Company has over 50 items of technology in the process of exploitation although it was only founded on 1 July 1988. This Company also has 18 patents of which some have already been licensed. Other universities have yet to set up planned science parks or technology centres. It is important that initiatives in the higher education sector and those originating in Government should be allowed time to establish themselves with manufacturing industry and that the funding environment in particular should be sufficiently stable to permit coherent planning and implementation.

FIGURE 1

Supply of Graduates 1988 and 1989

Covering universities of the United Kingdom (other than the Open University) also Polytechnics, 81 Colleges of Higher Education in England and Wales (IHE), and 15 Scottish Central Institutions (SCI) and Scottish Colleges of Education.

	1989 Estimate (thousands)[1]					1988 Actual				
First Degree (by Subject Group)	Univ	Poly	IHE	SCI	Total	Univ	Poly	IHE	SCI	Total
Education	1.3	2.0	3.2	0.6	7.1	1,511	2,017	3,662	518	7,708
Pharmacy/Pharmacology/Medical Health	5.8	0.8	0.03	0.4	7.03	6,377	768	99	343	7,587
Engineering & Technology	9.7	5.9	0.2	0.7	16.5	9,777	5,431	133	653	15,994
Agriculture & Forestry	1.2	—	0.1	—	1.3	1,235	—	77	—	1,312
Science	16.4	6.2	1.2	0.5	24.2	17,093	5,978	1,136	455	24,662
Admin. Business & Social Studies	19.3	9.8	1.5	0.8	31.4	19,226	9,434	1,387	714	30,761
Architecture & Professional	1.3	1.9	0.3	0.5	4.0	1,303	1,989	253	493	4,038
Languages	9.0	1.5	0.4	—	10.9	8,608	1,317	477	—	10,402
Arts other than languages	7.5	1.9	2.0	—	11.3	7,459	1,947	2,247	—	17,971
Art/Design		3.4	2.5	0.5	6.4		3,433	2,383	502	
Total: First Degree	71.5	33.4	11.4	4.0	120.1	72,589	32,314	11,854	3,678	120,435
Higher Degree	30.0	7.0	4.0	0.9	41.9	27,942	[1]7,000	[1]4,000	[1]860	39,802
Grand Total	101.3	40.4	15.4	4.9	162.0	100,531	39,314	15,854	4,458	160,157

[1] These figures are derived from the numbers "on course" at universities on 31 December 1988 and polytechnics at November 1988 by applying "experience factors" for wastage and course transfers. For institutes of higher education, and for Scottish Central Institutions, the figures are derived from details supplied by the Department of Education and Science and the Scottish Education Department respectively on enrolment for final-year courses. (The latter exclude Education figures.)

Memorandum by the Defence Manufacturers' Association

GENERAL COMMENTS

This investigation is welcomed by members of the Defence Manufacturers Association and we are pleased to see that innovation is considered to be the economically significant application of new knowledge and techniques. There has been a tendency in the past to concentrate Government attention only on invention and research, on the assumption that the follow-through would be automatic and not require Government assistance. The UK has always been at the forefront in the generation of new ideas and new technology but steadily falling behind the rest of the world in its ability to turn these good ideas into profitable products. Any moves to provide further assistance towards this objective would be most welcome particularly where this leads to the encouragement of well qualified and well motivated people to enter manufacturing industry. This touches on improved education, greater rewards and status and a general change of attitude within the industry and in the perception of industry from those outside.

MAIN POINTS TO EACH QUESTION

1. Companies that are reluctant to give priority to innovation in terms of providing high quality staff and sufficient funds in the face of rising interest rates and shrinking profit margins are the ones that are unlikely to succeed or even survive in the long-term.

2. Companies vary in their attitude to brought in technology. Some find the hurdles difficult, others have no choice while many constantly seek out innovation.

3. Product development and production engineering can both depend on technological innovation for their success. We could add a third heading of equal importance—product design—which can be equally or more dependent.

4. Small companies have been helped by various government initiatives but there is little there for medium and large companies and in some ways current policies inhibit the exploitation of technology through innovation.

5. Innovation in the City's eyes seems akin to high risk stocks—to be watched carefully for possible opportunities but not for investment until the product future is more secure.

6. Legislation is broadly neutral but financial help in the form of tax incentives could help.

7. Where little is known about the availability of information, support is lacking. More publicity and support is needed from Government.

8. Too little information is seen to be available and the well known programmes do not seem to favour the UK.

9. A good customer/supplier relationship is vital to satisfaction on all sides. There are problems where cut throat competition is enforced and where the risks inherent in the use of innovation are not recognised.

10. The factors are listed in the annex.

11. Relationships vary between the defence and civil sectors. We believe the ACOST report recommendations deserve firmer adoption.

ANNEX

Q1 *What are the effects of company attitudes and structures (including personnel policies, investment decisions)?*

Answer

Company attitudes and structures are of considerable importance in the encouragement of innovation. It is the overall innovation ethic and culture of the company which counts and success is the summation of the results of effort in many different directions. One should, therefore, look for the overall results of successful companies.

Attitude is the key factor affecting introduction of innovation. The most successful companies are those that encourage R&D, design and innovation, and regard them as the key to future profitability. The least successful (long-term) are those that regard these elements as cost centres to be cut back at the slightest sign of danger. However a negative response to innovation in many companies is understandable, given high UK interest rates, the poor status and reward accorded to engineers and scientists, and the lack of scientific training of many in senior management.

People feel more secure in routine low risk work because too often a high risk task is terminated and the staff transferred or made redundant. The effect of this is that very often people allocated to undertaking high risk innovative projects may themselves be "marginal or transitory" in that particular organisation. On the other hand, a company that takes the longer term view and consciously invests in its innovation will see that high fliers go into the key innovative slots.

Q2 *How active are UK companies in seeking out external technology, especially from overseas? How well do they adapt and apply it?*

Answer

The successful companies are good at seeking out appropriate technology to meet their needs. The source of new technology is rarely material to the eventual outcome. Good companies will endeavour not to re-invent that which they can obtain from other sources.

However there is a good deal of evidence—in machine tooling and production technology in general—that UK companies have little choice but to look overseas. In the defence sector, the MOD drive towards competition and off-the-shelf purchases, and its acceptance of non-British technology, is encouraging the trend. Cost effectiveness and profitability remains the key.

Some companies have a policy of actively seeking co-operative arrangements with other firms at home and overseas and others acquire technology by taking over firms.

One difficulty however is often the implementation of such technology by the workforce. This can involve severe cultural changes in the workplace including attitude training to overcome the "not invented here" syndrome.

Q3 *What are the respective roles played by product development and production engineering in technological innovation?*

Answer

Product development is understood to mean the activities of investment in product improvement, and concept transformation into "new" products, and technological innovation is a vital ingredient of these rather than an end in itself. Similarly, technological innovation can provide the means for obtaining improvements in production engineering, although the converse can also apply.

Any new product stems from demand and that demand, whether from a customer or a market generally, is the trigger for the development engineer. In most cases the development of a product depends on the proving of the scheme by the production engineer in a production environment. Therefore the new product may go back and forth between laboratory, proving at the development stage and production *per se*.

Product development tends to be more glamorous and to offer more short-term rewards, both to those carrying it out and to the Company. Process technology, on the other hand, takes longer to change. We are at last learning from the Japanese that it is the process technology that is all important and a shift in resource allocation is now underway.

Product development and production engineering are both important in technological innovation. A third topic should be added to this list—product design, which is equally important and often neglected.

Q4 *How effective are the activities of Government departments in promoting and supporting innovation?*

Answer

While welcoming the DTI and other Government initiatives in this area it is principally the smaller companies that benefit. The activities of Government departments are not always well targeted. They tend to be bureaucratic, requiring considerable time and effort to become engaged in them. The Governments of most West European countries are more supportive than that of the UK.

Some activities of Government Departments are considered counter productive in relation to innovation. On the one hand, free competition when applied to Government purchasing places undue emphasis on first cost and short-term considerations, encourages penetration of the UK market by overseas suppliers and does nothing to encourage the establishment of long-term viability of the UK industrial base. On the other hand, the policy of support targeted at pre-competition research produces basic technology freely available to all and which is often handed on a plate to our competitors, for instance, through European collaboration programmes.

Innovation is essentially linked to exploitation and present Government rules governing the provision of financial support specifically exclude the latter. Innovation is application specific and the more closely it is targeted to specific market requirements, the more worthy it is of support. Present policy effectively funds research and technology which is not necessarily going anywhere. Government support should be re-targeted towards the potential winners, technology which has a clear application and the development of that technology through innovation to successful products. This means supporting companies with an effective product strategy who, in most cases, will be the companies already successful in the market place. One possible approach would be through tax concessions for innovation, as already implemented in a number of other countries.

On some specific programmes mentioned by Members, there was a mixed reaction to specific initiatives. On design consultancy, there is considered to be a gap in the marketplace between the small company that can be assisted by DTI schemes and the large company that has no need of such help. Between them exists a large number of medium-sized companies with good ideas and very limited capital. A source of risk or venture capital for these companies is what is seriously lacking.

On initiatives concerning, for instance, the selection of computer aided design systems and the introduction of industrial robots there was limited enthusiasm for a wide variety of reasons.

Q5 *What are the effects of City attitudes to investment in innovation?*

Answer

Generally the City requirements for short-term performance do not encourage investment in innovation especially where the development will be prolonged and the return therefore some way into the future. However, a handful of the bigger institutions now seem to realise that a balanced longer term view is vital to guarantee future success.

There seems to be a preoccupation with companies share values, and firms' activities are therefore directed towards increasing share prices. One of the major ways of increasing share prices is to pay high dividends. Research and development investment is usually decided on the levels of profit, but after dividends have been paid. Research and development investment therefore tends to suffer.

Companies' strategies tend to be aimed at satisfying the needs of the Stock Market, rather than the "real" commercial market, drastically affecting research and development investment.

Q6 *What is the effect of the legislative and regulatory framework concerning, for example, labour costs, patent laws and tax concessions on R&D and the purchase of know-how?*

Answer

Legislation is broadly neutral in the UK whereas many countries actively encourage innovation by legislation and taxation. However there are problems with patents for small companies.

As a stimulant, tax incentives, in the form of more generous treatment of the investment of private venture funding for R&D or the acquisition of know-how, would help innovation in manufacturing industry. In the past, investment in capital equipment has been so treated.

Q7 *How effective are the mechanisms for technology transfer from HEIs, Research Councils and public laboratories to manufacturing industry?*

Answer

This is a difficult area since unless the mechanisms are working well, industry has little idea what is or could be available.

Unpromulgated research reports are of no practical use and the important issue is that information should be publicised to all who may have a justifiable need to know. The outputs from HEIs, Research Councils and public laboratories are of little value to Industry if they are not readily available. In the developed technology area such bodies may have little to offer defence firms but technologies and skills in problem solving for instance could well be relevant and apt.

The usefulness of special arrangements made such as the Defence Technology Enterprise (DTE) company have only slowly become recognised and effective but are generally gaining credence and support.

Q8 *Does the UK benefit sufficiently from EC support for innovation? How might it be improved?*

Answer

UK benefits from European Community support have, to date, been seen to be negative resulting in a net out-flow of technology and innovation from the UK. It is inevitable that any international programmes such as ESPRIT and EUCLID targeted at pre-competitive research and technology transfer will benefit the countries with less developed industries at the expense of those whose industries are already in a lead position. Support for innovation, as defined by the Select Committee, as long as it is fairly applied, should be of substantially greater benefit to UK industry. The only European industry-led programme targeted towards innovation, EUREKA, has been largely ignored by the UK Government because it did not meet their own rules for sponsorship.

The opportunities for EC funding need to be more effectively publicised and the bureaucratic machinery less daunting to potential users.

Q9 *What are the effects of the varying relationships between companies and their suppliers?*

Answer

The relationship between customer and supplier must be based on mutual trust. This cannot exist in a cut-throat competitive situation nor a monopolistic situation (the former can eventually lead to the latter). It is probably not in the long-term interest of the community if any company makes a loss on a transaction, and it certainly is not if that company ceases trading as a result. New technology inevitably introduces risks because its newness implies unknowns and inexperience. It is, therefore, not in the interest of a supplier to propose high risk technologically advanced solutions to a customer's requirements if it will lead to a loss, or (if he is perceptive enough to quantify the risk) lead to his being uncompetitive in the short term. Intense competition therefore, discourages user-benefits other than cheapness.

With the right relationships between customer and supplier new products can be developed jointly to mutual benefit. However this needs complete trust between the two parties (a) to ensure no breach of confidence by the supplier to other competitors and (b) when the product is developed to the production stage to ensure the benefit of a supply contract from the customer to the supplier.

However the relationship between companies and their suppliers is changing quite dramatically in recent years. For instance the automotive industry is forcing responsibility for quality performance through compliant adherence to specifications rather than to detailed product requirements. By having a tightly controlled list of approved suppliers and insisting that they force their standards of quality higher and higher, producers suffer less subsequent waste, reject or warranty claims. The improvement of qualified suppliers is towards the achievement of overall improvements in quality and reliability and in this respect sits somewhat at variance with a cost driven policy of competition.

Q10 *What factors influence decisions to invest in innovation in the UK or overseas?*

Answer

Some of the factors are:

1. The financial situation at the time. Can it be afforded? Is the money being used to best effect? What are the returns? and over what timescales?

2. The incentives and risks involved. Can risks be shared? Are there other benefits or drawbacks?

3. The resources and facilities required. Are they available? Do we want to commit them?

4. The marketplace. Is the new product/service likely to be needed? What competition is there and what advantage does it give in the short/medium/long term.

5. Image. What does it do for the Company image?

Q11 *In the light of ACOST's report "Defence R&D: A National Resource", and the Government's response, is there a satisfactory relationship between the defence and civil sectors?*

Answer

The perceived relationship between the defence and civil sectors varies depending on the technology area. In some—aviation and many electronic fields for instance—the relationship is good and improving (but there are often security problems).

For some years there has been a programme for transferring technology from Government R&D Establishments to Industry. The impact of the new Defence Research Agency has yet to be assessed and there are considerable reservations, particularly in manufacturing industry, as to how the thorny questions of IPR and design rights will be handled.

Nevertheless the general feeling is that civil applications of defence technology are few and far between. If there were common ground, one would expect to see civil products used more in military applications.

Technology is a volatile resource, primarily because it is vested in people, who move on for one reason or another, the most common being a change of job. The more frequently people change roles or companies, the more rapid is the degeneration of technological skills for the industry as a whole. This shows signs of worsening due to the scarcity of projects able to provide continuity in labour, and also due to the turbulence in the current job market. It used to be said that technology has a ten year half-life, but it is probably more like five years at the present time. When existing technology is so volatile, the ground cannot be fertile for newer technologies which are often nourished by the old.

Memorandum by the Defence Technology Enterprises Limited

OBSTACLES TO INNOVATION AND THE CONDITIONS WHICH STIMULATE INNOVATION

General Commentary

1. There is, primarily, a low awareness in many sectors of industry of the need to continuously innovate and to plan the process, i.e., too few companies have innovation on Board Agenda and rely on proposals bubbing up from the ranks. These tend to be proposals for incremental innovations, often to overcome technical problems perceived or experienced in production of existing products. Whilst these are important to be solved, the more strategic planning gets sadly neglected. So few companies seem to be able to respond to a question about their product and market plans for the next five years.

As a result they have no activity which could be described as looking outward to see what technological innovations have occurred and whether these could improve their product performance, product range, or enable them to diversify into something new which still fits their manufacturing expertise, market presence, etc.

DTE finds UK companies either difficult to persuade to put any serious management time into assessing the potential of our cases for their business, or decisions about taking a licence/option are very slow or are not made. This is often because too many individuals need to have a say in the decision and they do not have a strategic backcloth against which to decide yes or no—prevarication then rules! This is in stark contrast with US and Japanese companies where there is often a man (or a team) solely responsible for scouring the world scene for innovations of use to the company, which is implemented against a clear strategy/plan. They usually have:

1.1 A well organised system for evaluation of candidate cases.
1.2 Authority to make decisions whether to acquire.
1.3 The broad terms for the technology acquisition.

Many foreign (Japanese, US) companies actively broadcast their 5/10 year innovation plan to sources of technology and agencies of technology transfer. DTE is not aware of UK companies doing this on any significant scale.

2. We are frequently told there is no real shortage of wealth in the UK for risk-orientated innovation. It must be a cultural problem which inhibits real venturing. The City financial institutions and Venture Capitalists seem to prefer short-term "dead certain" investment rather than the riskier "could be a winner" types. This is why much more attention needs to be given to legal/fiscal incentives in the UK. The obvious one, regularly voiced over many years and in many previous reports on innovation, is the tax incentive

enjoyed in the USA (for example) or the automatic long-term backing from financial institutions in Japan when the innovation fits a pre-set strategic business area (often set by MITI). In UK we do not seem to have directed incentives (only the general one of reduced overall corporation tax, etc.) nor do we have a coupled up DTI/Financial strategy for markets in which we wish to be big in 10 years' time. Thus everything seems to be more left to random happenings, chance encounters or opportunities, and so-called market forces. The latter means you are probably running late or at best getting a "me too" product rather than USP (Unique Selling Position).

3. If we do succeed in getting something new under way (e.g., a new-start company with small measures of help at start-up) the forward needs of the innovating body never seem truly catered for—more a question of jump one hurdle and never mind whether there is grant aid or help for the next hurdle. This causes often disastrous stop-go performance and can account for many new ventures folding up or going into receivership.

4. The DTI Support for Innovation scheme went right away from anything near market—a policy change—but we believe this to be a mistake. We would not want to go back to exactly the old situation whereby Support for Innovation funds seemed to go primarily to big companies who perhaps needed it least. But to believe that industry, especially smaller companies, can take near market to market without help seems to be a complete misreading of what our financial institutions will/will not do for companies trying to innovate.

Please note that by summer 1990 there will be a very useful report out from a study funded by the European Space Agency (Work Package 2 by Segal Quince Wickstead of Cambridge). This is looking across all the ESA member states at what arrangements/schemes, etc., exist, or are being planned, to stimulate innovation and technology transfer, and what gaps still seem to remain. This report will be a major comparative study and should show how the UK fares with other European countries. DTE was the lead company and co-ordinated the bid to ESA against competition across Europe. We won Wk Pkge 1 (for ourselves) and 2 (for SQW).

Q1 *What are the effects of company attitudes and structures (including personnel policies, investment decisions)?*

To an extent it depends on the size of the company concerned. In large companies (especially defence contractors) the "Not Invented Here" syndrome is very strong and these companies feel that they are capable of tackling any problem in-house and that external technology is either suspect or not part of the core business. Smaller companies tend to be more flexible and will recruit against new projects and technology.

In most cases (though not all) investment decisions are based on reasonably sound logic and appropriate business plans usually in business areas close to or familiar to the company. In a number of cases decisions are based on gut-feeling or some other ill-defined parameters.

Both large and small companies seem to have a very poor awareness of what licensing means and how it can be used to generate income, form partnerships, share risk, and avoid expensive R&D.

Compare Japan, where all engineering graduates emerge with substantial training in patents, licensing, the innovation process. They then go into industry at least aware. Some Japanese University faculties have permanent legally trained people on their lecturing staff for this purpose. In UK?—one or two courses, often at M.Sc. level only, nothing much. Not even post-graduates get any training in thinking patents, innovations, intellectual property, etc.

Reward system to in-house inventors seems derisory or very poorly developed in most companies (c.f. Germany—much more organised).

Q2 *How active are UK companies in seeking out external technology, especially from overseas? How well do they adapt and apply it?*

Generally poorly. Larger companies may scan the scientific literature and implement ideas at a fundamental level. These are companies with large R&D budgets, libraries, etc. Many companies are unaware of the benefits of licensing technology from home or abroad; many companies want turn-key solutions too. There is some evidence that the situation is improving. More companies are appointing Business Development Directors to seek out new technology and, also, to utilise further in-house developed technology. There appears to be a reluctance in many countries to pay for an external technology no matter how good it is.

Q3 *What are the respective roles played by product development and production engineering in technological innovation?*

In Britain we are appalling in the way we treat product development and production engineering. There seems to be a deeply seated belief that the idea is 100 per cent of an invention and that the manufacturing is simple afterwards. In reality ideas are "two-a-penny" and the real, hard work is in obtaining the best economic yield, throughput and efficiency for a product, and delivering it to the customer at the right time and the right price. How this contrasts with Japan where research engineers take their ideas through on to the production line and learn the problems of high volume, low margin products! This is especially true in electronic components.

In the UK there is too great a gulf between the Research and Development ends of R&D. Our universities (or at least the red-brick ones) tend to produce individuals who at 21 are not much different from a school-leaver at 18 with little if any knowledge of the (manufacturing) world. Engineering is still perceived as a dirty, oily industry with little attraction when the City calls with its high salaries for sitting at a desk pushing paper and buttons. The Oxbridge universities still take too great a proportion of the university money and more should be channelled into technological universities and polytechnics.

We must start to realise the importance of product development and production engineering in our industries as a whole, and not believe that we need only accountants and marketeers in a successful industry. It is no good being a world leader in ideas (e.g., Nobel prizes) if we cannot convert these into manufacturing reality.

In the UK companies have tended to put in enough money to a business idea to get it into serious trouble. The idea just takes off and flops because it has been done on a shoe-string. The British LCD industry is a prime example of this. The majority of the liquid crystal materials (cyanobiphenyls) were invented in the UK and exploited abroad, mainly in Japan. They bring in attractive royalties for the UK company concerned (BDH) but no UK company invested in the technology to make the LCD's other than in a research environment. The complete UK investment for a technology invented here is less over 10 years than that invested in a single LCD line in Japan. One company, Hitachi, has 16 separate lines! Philips, only of the European companies, has licensed processes from Sharp and seen that it can compete in a worldwide sense with other LCD manufacturers. One last example is the "Supertwist" technology invented at RSRE and now present in virtually every lap-top computer display made. No UK company has made a single display of this type or has the capability yet it is still claimed in some circles that we are world-leaders in the technology!

Q4 *How effective are the activities of Government departments in promoting and supporting innovation?*
Is there a government policy in this area? The grants system is milked by those companies who know it best not who need it most. The large initiatives, e.g., Alvey, were dominated by one or two large companies. GEC played a part in 19 of the 26 Alvey projects. The smaller company is not getting a chance in this area. Publicity material is poor and unco-ordinated. Export licences are a nightmare for the small company. There is a lack of knowledge that licence fees can be a legitimate part of a grant claim from the DTI. However, more needs to be done on a European level. We cannot expect to compete purely on a (DTI supported) UK level and the move towards more European links and projects must be welcomed. These are difficult for the smaller more innovative companies to gain access to. The various consultants scheme are good, but few statistics are available as to its success or failure. Is the system being used by a few companies only? How many of the ideas go into production eventually?

Q5 *What are the effects of City attitudes to investment in innovation?*
There is a perception that financing property speculation is more profitable than financing high technology projects. This is understandable because the risk is higher in "high-tech" and investors have been bitten. However, venture capital for ideas only seems very difficult to get in the UK (contrast the USA) and collateral is often required to minimise the risk to the investor.

It could be summed up as too much short-term interest over-riding long-term profits and the inability of City Institutions to become actively involved in innovation at an early stage.

Q6 *What is the effect of the legislative and regulatory framework concerning for example labour costs, patent laws and tax concessions on R&D and the purchase of know-how?*
The legal/fiscal incentives for investment in innovation are virtually non-existent with no tax benefit and poor patent law. There is still much to do to improve and develop patent law (US system far better—one can actively market and "test the water" for industrial interest in a new idea and still patent 12 months later when one knows something about its commercial potential). Having to patent, or keep it secret and close to your chest because you cannot afford patenting, is a big inhibitor of market assessment, partnering, licensing, etc.

Q7 *How effective are the mechanisms for technology transfer from HEIs, Research Councils and public laboratories to manufacturing industry?*
The situation is improving rapidly. Many universities and educational institutions have some form of technology transfer unit. Many companies are working with universities from the SERC CASE awards up to endowed seats in key areas. However, transfer is very much on an *ad hoc* basis, and the transfer mechanism seems to suffer from lack of commercial and legal expertise in HEIs, Research Councils and Public Laboratories. There is no overall co-ordination of activity. Perhaps there is a need for one technology transfer type magazine or similar where all institutions can contribute. At the moment there are a large number of separate technology transfer organisations (e.g., BTG, DTE, research organisations like SIRA, ERA, PIRA, GAMBICA, university/public laboratories) and it must be difficult for a small company to know where to turn to.

Q8 *Does the UK benefit sufficiently from EC support for innovation? How might it be improved?*
EC is more active in R&D—and UK has a high share of this. For innovation as defined in the questionnaire, EC does not have so many schemes, but those that do exist usually require co-funding by

companies and intra-European partnerships—UK does not seem very good at finding the partners c.f. Holland+Belgium, or France+Germany, where there seems to have been a much longer tradition of cross-frontier collaboration and trading. Again, it seems to be the larger companies who benefit from ESPRIT, SPRINT, RACE, etc.

Q9 *What are the effects of the varying relationships between companies and their supplier?*
Supplier and user relationships in this country are still extremely bad. Users wish, for the most part, to get suppliers to supply them with goods at the cheapest possible price. They fail to take into account such things as quality assurance, on-time delivery, reliability, etc., and if more companies would take the attitude of companies such as Marks & Spencer, in developing good relationships with their suppliers, then not only would the customers get better products, but the suppliers would be more profitable. The relationship between companies and their suppliers is changing rapidly for the better with the advent of quality systems (BS 5750/ISO 9000) and the philosophy of Total Quality Management.

Q10 *What factors influence decisions to invest in innovation in the UK or overseas?*
The usual ones—mainly economic (interest rates, discounted cash flows, NPV's, labour and manufacturing costs). Availability of labour can influence a decision and this may include language. UK firms have stronger tie-ups with US firms in many instances than say firms in France.

Q11 *In the light of ACOST's report "Defence R&D: A National Resource", and the Government's response, is there a satisfactory relationship between the defence and civil sectors?*
Too much of the UK's R&D budget (50 per cent) is still tied up with the defence sector. Big defence contractors have been "cotton-woolled" by MOD and are unwilling to invest their own resources. MOD has in the past paid for contractual research *and given* the companies the associated Intellectual Property Rights. This is changing slowly. Smaller companies need the opportunity to work within the defence field without the burdens of "qualification" and long tendering documents. MOD's move to DRA may make it more "commercial", but it needs to get involved more directly in projects, e.g., its own manufacturing lines for key components, some of which could be sold on. This would be preferable to relying on a clique of old-boy defence contractors. Also there are key technologies it possesses (e.g., carbon films) that could be turned into stand-alone business ventures. More commercially aware sales and marketing and production people need to be involved with the MOD. The DTE initiative is excellent, but it needs more direct co-operation from MOD in the risk sharing. Many companies are unaware that they can tap the resources of the MOD via DTE and a technology transfer unit (into and out of of MOD) within the MOD would be very attractive. Many companies have problems that could be solved (on a consultative basis) by MOD.

Supplementary Memorandum by the Department of Trade and Industry

INWARD INVESTMENT

1. The Department of Trade and Industry promotes inward investment in the UK to foreign companies through the Department's "Invest in Britain Bureau" and its Regional Offices. The main reason for encouraging such investment is for wealth and job creation.

2. Inward investment increases wealth by creating production capacity for new products and processes and by introducing or stimulating the use of more efficient management techniques. Currently the latest wave of Japanese investment is leading to improved efficiency and international competitiveness in a range of component suppliers (e.g., 100 per cent quality and Just-In-Time delivery) as Japanese purchasers work with UK-based suppliers. Foreign investment is a significant contributor to manufacturing activity. The Annual Census of Production, 1987 shows that foreign owned businesses accounted for 13 per cent of employment in manufacturing, 19 per cent of net output, and 21 per cent of capital expenditure. At local levels, many authorities throughout the UK actively promote inward investment as a means of increasing prosperity and improving the range of the job opportunities. They co-operate readily, as members of the national network of promotional agencies, in the work of the Invest in Britain Bureau, which since its foundation in 1977 has recorded more than 300,000 jobs created or safeguarded by inward investment projects.

3. Most inward investment involves state of the art manufacture of a mature product which already has market share. The normal evolution is for assembling of the mature product to be followed by domestic manufacture of brought-in components, in-house modifications to cater for domestic tastes, and finally, full local control of design, production and marketing. The location of research and development in a domestic facility is usually the last stage of all to occur. In some circumstances this normal evolutionary cycle is speeded up, e.g., Nissan Car's European Technology Centre in the North East and Sharp's Electronics R&D Laboratory at Oxford.

4. It is important when considering the significance of inward investment for innovation to establish its quality. Initially a "screwdriver" facility may exist with imported parts from the company's overseas base merely being assembled. Gradually a more autonomous unit drawing on local supplies, may evolve which begins to undertake its own development work. Information flows from customers and suppliers will tend

to suggest ideas, for product and process refinement; hence the production unit will become innovative and, by demanding higher standards from local suppliers, will provide further pressure to innovate. US companies which have been in the UK for a substantial number of years have often reached this stage of development, e.g., IBM and Hewlett-Packard. The more recent arrival of Japanese companies makes it likely that pressures to innovate will be sustained.

5. The following Japanese firms already have a research and/or development function in the UK: Canon Research (information technology), Eisai Europe (pharmaceuticals), Yamanouchi (pharmaceuticals), Koble (plastics), Aishin Seiki (car components), Nissan and Fujitsu (microelectronics)—4M DRAM production, with some associated R&D likely to grow).

6. Such R&D facilities tend to have one of three functions:
   (i) Customising the product for local needs and official standards.
   (ii) As an independent facility able to carry out both basic and applied R&D exploitable in domestic and world markets.
   (iii) As part of a network of facilities which draw on specialised local competences and which are integrated into a global R&D strategy.

Each of these types of development have different implications for domestic economic growth and the accumulation of factor skills.

July 1990

Memorandum by the Design Council's Innovation Centre

The Design Council's Innovation Centre is in touch with many inventors each year and holds discussions with companies about the development of specific new products.

In summary, experiences of the Innovation Centre are relevant to the following sections:

2. *Take-up of External Technology by UK Companies*
   2.1 A fall in demand for contracted work appears to have stimulated some companies to look for new ideas and technologies for in-house development.
   2.2 There is reluctance to take up new ideas and techniques, particularly those from individual inventors.
   2.3 An Innovation Centre survey of companies' attitudes to innovation and take-up of new ideas suggested that although companies recognise the importance of looking outside for new ideas to develop, the number of companies which actually use new ideas is low.

4. *Promotion and Support of Innovation by Government Departments*
   Government schemes promote and support innovation to a certain extent, but more support is needed for early stage ideas.

5. *City Attitudes to Investment in Innovation*
   5.1 Investors are reluctant to take risks with early stage ideas.
   5.2 Biotechnology: An exhibition in the Innovation Centre has highlighted some of the obstacles to innovation in this area.

2. TAKE-UP OF EXTERNAL TECHNOLOGY BY UK COMPANIES

2.1 A fall in demand for contracted work, such as manufacturing and tool making, appears to have prompted some companies to produce a significantly greater proportion of proprietary products. The Innovation Centre has examples of large plastic manufacturers whose business until recently was made up of approximately 70 per cent contract work and 30 per cent proprietary products. They are endeavouring to reverse these percentages within the next five years. The result of this is an increased willingness to look at new ideas and technologies coming from outside the companies.

2.2 However, company attitudes to innovation are not necessarily encouraging, especially their attitudes towards individual outside inventors. The Innovation Centre has an interesting example of an idea, a new wheelbarrow design, which, for years, failed to be taken up by companies approached by the inventor, but now has firm interest from a number of companies as a result of introductions made through the Design Council.

Very few companies produce guidelines for inventors wishing to approach a company with an idea, explaining how inventors should go about getting their idea to an appropriate stage of development and how they should write a suitable business plan or proposal.

2.3 Innovation Centre Survey

A large number of companies have a company policy which does not encourage the take up of ideas from outside their own R&D departments, partly because they feel that this reflects badly on their own R&D departments.

In 1988 the Innovation Centre conducted a survey of British companies' attitudes to innovation. Some of the results of this survey relate directly to the activity of companies in seeking external technology.

The survey was conducted by questionnaire and sent to all companies on the Innovation Centre mailing list in January 1988.

A copy of the results of the questionnaire is enclosed and the relevant sections are as follows:

1. Origin of the mailing list.
2. The questionnaire.
3. Statistical analysis.
4. Statistical results of questions sent to general engineering/manufacturing companies on the Innovation Centre mailing list. In particular, questions 17, 18, 19, 22.
5. Comments on the statistics results. In particular, paragraphs 1, 3, 4.

4. PROMOTION AND SUPPORT OF INNOVATION BY GOVERNMENT DEPARTMENTS

Schemes such as the Enterprise Initiative can play a part in encouraging innovation in their use of a range of "tools" aimed at increasing the competitiveness of British business. However, many inventors are initially seeking to get their idea to a stage of development, at which they can pass the executive management of the project onto a company with the right facilities and expertise already in place including manufacture and marketing networks. Government schemes tend not to be supportive of the early stages of the innovation process. If the inventor has not formed a company and has some sort of management structure in place, and even proof of initial orders, it will be difficult to obtain Government support. The DTI's Small Firms Merit Awards for Research and Technology (SMART) is open to individuals but they must intend to start a new, independent firm in the UK. Also SMART Awards are given to a limited number of innovative developments—about 150 each year.

5 CITY ATTITUDES TO INVESTMENT IN INNOVATION

5.1 The Individual Inventor:

Inventors require guidance on how to get the idea to a suitable stage of development so that a company can assess the idea with a view to taking the idea on. Costs of patenting, market research, toolmakers, design consultants, model makers, are often prohibitive to an individual.

Since these costs are related to the very early stages of development of a project, companies tend to be reluctant to pay these costs and assistance is required from another source. Banks and city investors do not provide money for projects unless there is a very good, proven chance that it will succeed, and within a set timescale. At such an early stage of the project it is very difficult for an inventor to be able to prove the likelihood of success, and thus applications for finance are often turned down by banks and other potential investors.

5.2 Biotechnology and Innovation:

An exhibition running in the Innovation Centre until 1 June has highlighted some of the problems which companies involved in high technology projects have in raising finance. Several companies included in the exhibition, BIOTECHNOLOGY: INVESTING FOR THE FUTURE, have experienced reluctance amongst City fund managers to put money into projects which may not come to fruition for many years.

Several factors appear to be contributing to investors' caution:

- Over expectations concerning the commercial returns of biotechnology—considerable investment in biotechnology companies in the US in the late 1970s and early 1980s failed to deliver returns at the speed projected.
- UK firms lack personnel with expertise required to manage innovative projects.
- Venture capital funds generally have a limited lifespan with expected periods of realisation sometimes as short as five years—many biotechnology projects will take much longer than this to come to fruition and so do not attract some forms of venture capital.

An exhibition brochure is enclosed *(not printed)*. Companies which have had particular difficulty in attracting venture capital include Scotgen Limited (page 5) and OV Limited (page 9). BEAM Tech Ltd (page 8) also found the finance was difficult to raise in the early days of its existence.

BACKGROUND TO THE INNOVATION CENTRE

The Innovation Centre, situated within the Design Council's exhibition space in the Haymarket, was opened in September 1985 in order to display the latest ideas in technology and innovation. Since its opening, the Innovation Centre has put on show over 700 exhibits including a wide range of new products, prototypes and techniques drawn from universities and polytechnics, research establishments, companies and individual inventors.

The Innovation Centre also provides a comprehensive information service on all aspects of the innovation process and has an inventor's self-help scheme called NoticeBoard.

NOTICEBOARD

NoticeBoard is a scheme which aims to link innovators with companies which may be able to assist them further. Staff from the Innovation Centre can give the inventor help including business information, business plan formulation counselling, design protection advice and can refer the inventor (if necessary) to appropriate sources of professional help. There are some projects which reach a suitable stage of development for the Innovation Centre to introduce the idea to companies, and sometimes this results in the company taking up the idea.

INNOVATION CENTRE QUESTIONNAIRE

1. *Origin of the mailing list*

The Innovation Centre's mailing list was originally taken from ENGINEERING magazine's contacts (ENGINEERING magazine is a Design Council publication). All the companies on this list (estimated to be about 8,000 of them) were mailed and asked to indicate whether they were interested in receiving regular information on the Innovation Centre. The majority of these companies are from Group 3 in the Standard Industrial Classification which covers Original Equipment Manufacturing. Those that agreed to be on this mailing list make up the majority of the total (about 10,000) on the mailing list. Approximately 2,000 of the total are individuals/companies which have expressed a wish to be included on our mailing list since the opening of Innovation Centre. They have either visited the Innovation Centre exhibition space or contacted the Innovation Centre for help as inventors in order to use the services as outlined on the Innovation Centre Services sheet.

2. *The Questionnaire*

The questionnaire was sent in January 1988 to all on the mailing list. The percentage returned to the Innovation Centre was approximately 3.5 per cent (at the time of writing this some were still coming back).

The questionnaire can be divided into three types of data. Questions 1-8 inclusive are about the company. Questions 9-14 relate to how a company would be prepared to help inventors. Questions 16-25, except question 23, give statistical information about innovation in the company. The rest of the questions concern comments and general information.

3. *Statistical Analysis*

It was decided that the first 300 questionnaires would be statistically analysed. Of the first 300 questionnaires, for each question a percentage of companies did not answer. The percentage that did not answer differed for each question and this percentage could not be correlated between questions. The number that did not answer (No Answer) is expressed as a number (out of 300). The number that did answer is divided up as a percentage according to how they answered.

The statistics were calculated so that the results for each question represented the percentage of *companies* answering each option.

For questions that requested answer (a) OR (b) OR (c) exclusively (i.e., all statistics questions except 22) some companies answered twice or three times, e.g., (a) AND (b). For this example the company was counted as half option (a), and half option (b) (i.e., equal statistical weighting) provided it was thought to be relevant and the combination of answers made sense. If they answered all three then this was divided into thirds provided the combination made sense. If the combinations were nonsensical, e.g., answering both YES and NO to Question 20, then the company was omitted from the statistical count.

For Question 22 most companies answered more than one option since the choices offered were not mutually exclusive, i.e., any of the three options in any combination were feasible answers. This question has been further anaylsed to show what per cent of companies answered specific combinations of options.

The final statistics show the percentage of companies that include (a) in the answer, then the percentage including (b), etc., and includes those that ticked more than one option.

4. *Statistical results of questions sent to general engineering/manufacturing companies on the Innovation Centre mailing list*

Analysis of the first 300 completed questionnaires.

Q16 *What do you think of the present level of innovation in your sector of British industry?*

	Average per cent (c to 1 d.p.)	No answer or void (out of 300)
High	12.4	6
Sufficient to maintain competitiveness	39.1	
Low	37.3	
Too low	11.2	

Q17 *How do you feel your sector of British industry competes with similar companies from abroad?*

Well ahead of competition	8.6	11
Keeping pace	62.9	
Falling behind	28.5	

Q18 *Do you consider innovation to be:*

Important to business	95.5	1
Informed of, not involved	4.2	
Not necessary to business	0.3	

Q19 *Do you think that innovative ideas from outside your own company are:*

A good source of potential new products	61.2	11
Sometimes useful	34.8	
Only useful if already developed	4.0	
Not useful	0.0	

Q20 *Does your company have its own R&D department?*

Yes	69.4	6
No	30.6	

Q21 *How many people work in the R&D department?*

0-5	52.2	74
5-10	16.4	
10-20	15.0	
>20	16.47	

Q22 *Are new ideas generated for the R&D department from:*

(a) Within R&D department itself	35.7	67
(b) From other sections in company	37.2	
(c) outside the company	27.1	
Breakdown of answers:		
(a) only	12.0	
(b) only	16.3	
(c) only	7.3	
(a) and (b) only	18.0	
(b) and (c) only	6.0	
(a) and (c) only	7.3	
(a) and (b) and (c)	33.1	

Q24 *What percentage of your current sales comes from products updated within the last five years?*

Less than 10 per cent	15.0	40
10-20 per cent	20.4	
20-50 per cent	27.3	
50-70 per cent	18.5	
>70 per cent	18.8	

Q25 *What percentage of your current sales comes from new products introduced in the last five years?*

Less than 10 per cent	20.4	35
10-20 per cent	28.7	
20-50 per cent	24.1	
50-70 per cent	9.8	
>70 per cent	17.0	

5. *Comments on the statistics results*

The statistical analysis of the first 300 completed questionnaires shows some interesting trends, illustrating need for innovation to take a greater part in industries in this country.

Few companies thought that the level of innovation in their respective sector of industry was high. Over three-quarters of those answering Q16 judged the present level of innovation to be either sufficient to maintain competitiveness or low, with approximately the same number of companies choosing each of these two options. The remaining quarter were roughly equally distributed between an opinion of a high level of innovation in their sector of industry and too low a level. Considering the distribution of the percentage of companies choosing each option, the median* lies somewhere between a sufficient level (of innovation) to maintain competitiveness, and a low level. It would have been more encouraging to find the position of the median suggesting more companies think that the level of innovation is sufficient.

The majority of companies answering the questionnaire judged that their sector of industry is only keeping pace with similar companies abroad. Only a few felt they were well ahead of foreign competition and nearly a third thought they were actually falling behind. Despite the fairly low level of innovation, with companies generally only keeping pace with competition from abroad, nearly all of them considered innovation to be important to business.

Nearly all of the companies thought that ideas coming from outside their company were either a good source of potential new products or at least sometimes useful (Q19). And yet less than a third of companies have at least some new ideas generated for the R&D department from outside the company (see Q22 option c-outside the company), with the majority of ideas coming from within the R&D department or from other sections in company (Q22). Nearly half of the companies have had no ideas at all generated from outside the company (Q22, [(a) only] + [(b) only] + [(a) AND (b)]). Hence there seems to be a large imbalance between the way in which companies regard the usefulness of outside ideas and how many companies actually take on ideas from outside.

Once the results have been normalised so that the results cover equal percentage ranges (same bin widths) the mode* falls in the 10-20 per cent range in both Q's 24 and 25, i.e., most frequently 10-20 per cent of current sales came from products updated or introduced in the last five years.

Around two thirds of companies have their own R&D departments which are small on the whole, but the size of the R&D department depends on the size of the company. The fact that one third of companies have no R&D department is not significant since not all companies on this mailing list require research departments.

There are certain areas of British industry covered by the Innovation Centre's mailing list (see (a) Origin of the mailing list). Those that responded to the questionnaire appear to cover approximately the same sectors as the mailing list in about the same proportions. It appears that the level of innovation in these sectors of indstry is too low if Britain is to compete effectively overseas. The importance of innovation is not underestimated by the companies concerned but in reality the numbers of companies using ideas from outside for new products is low relative to the perceived importance of the input from outside.

JACQUI LEE
Innovation Centre
June 1988

Median*	In statistics it is the value of a quantity such that exactly half of a given population have greater values of that quantity.
Mode*	In statistics it is the value of a variable corresponding to its greatest frequency of occurrence.

Letter from Electra Innvotec

Electra Innvotec Limited is a venture capital management company concerned more especially with spinning out innovations from manufacturing companies and with other forms of corporate partnering. For example we manage a fund of £15 million for venture capital investment on behalf of British Gas plc.

In answering the questions in your letter, I have to say that, though we have wide experience and firm impressions related to innovation in manufacturing industry, none of this constitutes real evidence. Our answers—for what they are worth—follow, using your numbering.

Q1 Through its policy of assisting spinouts, Electra Innvotec has been involved with innovation in some of the largest companies in the United Kingdom and in some very small companies. It is our experience that differences between companies in their approach to innovation are more a function of attitude and structure than of size. Some large companies have very strongly innovative attitudes coupled with an organisation structure which allows and even encourages innovation to take place whereas others, often running down their research activities, are much more cautious. Large companies with decentralised organisations tend to be on the cautious side.

With regard to size, the main difference is that more attention is paid in the larger company to rigour in development, leading to a product which reaches the marketplace in a more ready state. Smaller companies often tend to do their homework in public, through shortage of resources and perhaps being more inclined to take risks.

Q2 Again, companies differ widely. One aspect of Electra Innvotec's business is helping large groups to invest in innovative small companies, usually to obtain technology. Some of the technology we come across has been obtained from overseas, usually under license. We have no evidence that UK companies are less adept at applying this technology than companies abroad. Aside from grant support, we have found the activities of various NEDO committees very helpful.

Q3 Not able to comment.

Q4 We are not able to comment on the promotional aspects of Government departments. However we have invested in a number of companies which have obtained DTI or DEn grants for innovation or support under the DTI Business Improvement Services scheme. Perhaps by ensuring a well thought through business plan has been presented, we have found a very supportive attitude from the Governmental officials concerned.

We have, however, found there is a shortage of Governmental financial support at the next stage, when innovative ideas, perhaps researched with partial Government support, have to be commercialised. The risks, particularly for a small independent company which has no reserves of finance or management on which to draw, are often too large even for consideration by venture capital. Otherwise promising technology and earlier financial support is thus often lost.

Q5 As a city investor, primarily in innovation, it is difficult for me to answer that question. However we have found it more difficult recently to attract partners in large venture capital investments where a strong element of innovation is present.

Q6 Not able to comment.

Q7 We have not generally been involved with technology transfer from HEIs, Research Councils and public laboratories to manufacturing industry.

Q8 In general, for one project in particular, we have found the EEC very supportive and helpful. Besides making substantial grants to the project, they are organising a conference at which the technology will be explained. One problem, as with most such bodies, is that of access in that businesses, particularly small companies, do not always know the department or the person to speak to.

Q9 Not able to comment.

Q10 Within Electra Innvotec we always look for a product that has been taken to the prototype stage or a process running at pilot scale, and having good potential market. The product or process should in general be capable of being exploited at least throughout Europe and if possible in North America as well.

Q11 Not able to comment.

I hope that these comments are helpful.

PETER J DOHRN
Director
5 *April* 1990

Memorandum by the Electronic Components Industry Federation

INTRODUCTION

The Electronic Components Industry Federation (ECIF) is the trade association representing manufacturers in the UK of all types of electronic components, ranging from integrated circuits ("chips") to relays, switches and connectors. Components are the key building blocks from which all types of electronic equipment and systems are assembled, and since it is frequently the performance of the advanced components which determine the performance of new equipment and systems, it is apparent that the electronic components industry has a key role in the innovation process.

ECIF would regard "innovation" as including the design of new products and the introduction of new manufacturing processes; it is assumed that this is covered by the Sub-committee's definition of innovation ("the economically significant application of new knowledge or techniques"), and that "new" in this context means new to the company concerned, and does not refer solely to newly discovered knowledge and techniques.

Finally it is worth mentioning that a leading components manufacturing company in the UK has recently conducted some research about public perceptions of innovation and innovatory companies; this has produced disturbing evidence that much of the public associates innovation primarily with the world of fashion and "gimmickry". It is to be hoped therefore that the Sub-committee's enquiry will help to correct this and draw attention to the fundamental importance of innovation to the economic success of manufacturing industry.

Q1 *What are the effects of company attitudes and structures (including personnel policies, investment decisions)?*
Company attitudes and policies are obviously of critical importance. One important inhibiting factor is the generally low standing of qualified scientists and engineers within British industry, reflected in their generally inadequate level of remuneration; this of course is to a considerable extent a reflection of general attitudes in British society towards scientists and engineers. With regard to investment decisions, these are certainly constrained especially amongst small- and medium-sized firms by current economic circumstances, and in particular the high cost of money.

A helpful development, of recent years on the other hand is the substantially changed attitude of trades unions towards innovation, which is no longer resisted in most areas but readily accepted and even welcomed.

Q2 *How active are UK companies in seeking out external technology, especially from overseas? How well do they adapt and apply it?*
Underlying this question appears to be an unspoken assumption that "external technology, especially from overseas" is in some way particularly desirable; such a generalisation in ECIF's view goes too far. No one would suggest that the UK can be completely self-sufficient and up-to-date in every field of technology, and the extent of dependence on foreign technology varies from industry to industry. In ECIF's view it is the effective application of new technology which is the crucial factor, rather than its source.

In the electronic components industry in the UK, there is a strong presence of multi-national companies with headquarters and operations in one or more other countries; such companies provide a ready channel for cross-fertilization of technology between the different countries in which they operate, and the pace of innovation in their UK operations is likely to be determined as much by their parent company's policies on innovation as by local factors.

In this connection, the position of new inward investors in the UK is important. Such companies normally start by establishing a market position with imports, then proceed to assemble imported kits of parts, and eventually move to full local production with a substantial local content of materials and components. But unless they take the further step of establishing local research development and design facilities, then such operations are unlikely to be the early beneficiaries of innovations originating elsewhere in the multi-national group.

Q3 *What are the respective roles played by product development and production engineering in technological innovation?*
Successful innovation requires that the production process should be taken into account from the beginning of a project. In other words product development and production engineering do not have separate roles, but are essentially integral parts of the same process. It is a weakness in the UK that the training of development engineers pays scant attention to production engineering.

The integrated nature of the two activities is very well illustrated in the integrated circuit (ic) industry, where each new generation of product not only requires, but frequently is initiated by, advances in production technology. Unlike industries where an existing production line can produce new models by a change of dies or by computer control, a new integrated circuit generally involves a totally new production line. And because the pace of technological advance in this industry is so rapid, lines costing £100 million or more frequently become obsolete before normal "pay-back" can be achieved. The price of remaining in the forefront of this highly innovatory industry is therefore very high.

Q4 *How effective are the activities of Government departments in promoting and supporting innovation?*
In the past, a number of Government schemes for the promotion and support of innovation have been useful and effective; notable examples are DTI's Microprocessor Application Project (MAP) and Micro-electronics Industry Support Programme (MISP). MAP was aimed at encouraging innovation in all sectors of industry and commerce by the application of innovatory micro-electronics techniques, and was subsequently emulated by a number of other countries. MISP was designed to encourage investment in modernisation of the micro-electronics industry itself by offsetting the high cost of such investment referred to in answer to the previous question and the difficulty of achieving a satisfactory return on investment judged by normal criteria. The funds made available for MISP by the Government were very limited however (a fraction of those being deployed to the same end by France and Germany at the same time), with the result that individual grants were too small a fraction of the total costs involved to have a substantial influence on investment decisions.

Such support schemes now have virtually ceased to exist and those that remain are less effective since they are constrained by arbitrary conditions such as the requirements to involve educational institutions and that all projects must be collaborative, together with the strong emphasis placed on small- and medium-sized firms.

Current concentration on support only for pre-competitive research ignores the fact that a crucial stage in the innovation process is the translation of research and development into "economically significant applications"; this is vastly more expensive than R&D, and consequently the area where it would be most logical to apply Government support. The argument that market forces alone should determine decisions in this area ignores the fact that the world market in key technologies such as micro-electronics is far from free, and is seriously distorted both by structural factors and in many cases by the deliberate policies of other governments who recognise the importance of these key technologies and are determined to ensure that they have a strong competitive capability in them.

The climate for innovation in the industry might be greatly helped if Ministers in their public declarations gave as much support, encouragement and praise to innovatory British companies as they do to inward investors.

Finally ECIF would like to draw attention to a specific situation with regard to the Ministry of Defence. For many years through a branch known as CVD, the Ministry provided financial and technical support for a certain amount of development of new electronic components in anticipation of specific requirements related to particular defence equipment projects. Advanced components which would not have been developed without such assistance have subsequently found their way into many current defence equipments. Unless such semi-speculative advance development of new components is undertaken, then the innovatory process is liable to be considerably prolonged, or alternatively the designer of a new piece of equipment is forced to rely upon those components available off the shelf, which necessarily will not represent the latest "state of the art".

In the absence of any support from MoD, the whole risk of such development would have to be borne by either the component manufacturer or the equipment company. It is understandable that neither should be very ready to do so, particularly in the current era of highly competitive procurement, when foreign suppliers are actively encouraged to seek MoD business, and there is no assurance that even if a British company undertakes successful development of a project, it will receive the long-term production orders which alone could justify investment in development.

Consequently there is a real risk of erosion of the UK's defence technological infrastructure in electronic components.

Q5 *What are the effects of City attitudes to investment in innovation?*
Innovation, particularly in advanced industries such as micro-electronics, requires above all what has been called "patient capital". The City of London is not famous for providing such funds, and whilst there are organisations which specialise in providing venture capital, these are in the fringes of the market. In general innovation is equated with a high level of risk, rather than being seen as essential to the profitable survival of a company.

Why this should be so is not easy to see; one possibility however is that the City has in the past not provided itself with adequate sources of technically knowledgeable advice, which has led to ill-advised investments in apparently innovatory companies in the past, and that such disappointing experiences have brought into disrepute the whole idea of investing in innovation.

Q7 *How effective are the mechanisms for technology transfer from HEIs, Research Councils and public laboratories to manufacturing industry?*
HEIs are regarded by industry primarily as a possible source of technical ideas with the additional capability to carry out a limited feasibility study of the initial proposal. Industry's role is to take the idea, complete the feasibility study and carry out the development necessary to provide a usable product.

Research Councils are regarded by industry as the catalysts for co-operation between HEIs and industry. The electronic components industry comes within the remit of SERC (Science & Engineering Research Council). In general SERC is seen in the Electronic Components sector as effective in providing platforms for co-operation between industry and HEIs. A number of schemes are seen as useful.

- Co-operative awards in Science and Engineering (CASE Studentships). The student spends three months with the partner. Industry obtains a useful access to student, tutor and university expertise. The scheme provides training for the student and a useful transfer of know-how to industry.

  There has been a problem with department heads in some of the older universities who give priority to filling Quota Studentships, leaving little resource of CASE Studentships. This is beginning to change as the benefits of a liaison with industry become appreciated.
- Co-operative grant (SERC). Formal agreement to the research proposal with agreement that the intellectual property rights transfer to industry on completion. This requires substantial contribution from the industry partner in funds and resources. It provides a useful entry to fundamental research over a significant timescale.

  A major problem may develop over the ownership of the intellectual property rights of any successful outcome. The pressure for HEIs to become increasingly financially independent is understandably making them more aware of the potential financial gains of a scientific breakthrough and brings a desire to benefit in any financial gain. Formulae to contend with this situation need to be developed.

- Teaching company scheme which extends the co-operative grant scheme to focus on a particular industrial problem with an expectation that university workers will join the industrial sponsor are particularly well regarded by industry. It accelerates the research because industrial pressure naturally results in time constraints and encourages, almost forces an intense interchange of information between partners. The expertise is transferred to industry as the university scientist joins the industrial sponsor at the end of the project.
- Fellowship schemes designed by SERC and the Royal Society to facilitate co-operation have perhaps disappointingly been under-utilised. Designed to use the more mature university scientist, perhaps there has been an understandable reluctance to change in mid-career. This scheme could usefully be better exploited by both parties because it has brought considerable benefit when used.
- Link schemes fostered by the DTI to facilitate consortia consisting of HEIs possibly Government establishments and industrial companies to tackle a research programme have had a slow introduction because of the unreasonable length of time taken by the DTI to accept proposals. Proposals agreed between consortia partners take 18 months-2 years to be accepted by the DTI by which time the members of the team have dispersed to other commitments.

In general the value of a working liaison between the electronic components industry and HEIs is appreciated and it is felt SERC is enterprising on the schemes provided.

Q8 *Does the UK benefit sufficiently from EC support for innovation? How might it be improved?*
ECIF is unaware of any substantial benefits to the UK electronic components industry from EC support for innovation to date.

There is however an urgent need for EC support for a European integrated circuit industry, and the UK should benefit from such support.

It is generally accepted that integrated circuits are a key enabling technology for any advanced industrial economy, and a key factor in innovation. EECA (the Euopean Electronic Component Manufacturers Association, of which ECIF is the UK member) has been engaged in continuing discussions with the European Commission over the last three or four years about the need for action by the EC to ensure that this capability is available in Europe, and had received a generally sympathetic hearing. It is therefore doubly disappointing that a report recently prepared by a group of experts which is due to be discussed by the Council of Ministers at the end of May, after setting out at length the importance of the industry, the problems from which it suffers, and the need to ensure that the technological capabilities of the industry are effectively translated into timely investment, then reaches the surprising conclusion that "there should be no special sectoral regime for investment in semiconductors". If this line is adopted by the Council of Ministers, the Community (including the UK) will have considerable difficulty in ensuring the availability to its industry of this key innovation-enabling technology.

Q9 *What are the effects of the varying relationships between companies and their suppliers?*
Close relations between customers and suppliers are of crucial importance in the electronics industry. Electronic equipment manufacturers and the suppliers of component are interdependent—neither can thrive unless the other also is successful. Traditional adversarial attitudes between customers and suppliers are outdated and shopping around for the cheapest possible source of supply and placing orders for small quantities at frequent intervals are not conducive to investment in innovation by the suppliers. Long-term relationships of mutual confidence (such as are commonplace in competitor countries, notably Japan, but regrettably much less so in the UK) are essential in the age of "just-in-time" and "total quality". Equipment companies need to be prepared to establish close relations with a small number of suppliers and discuss with them at an early stage their ideas about innovative future products, so that the component supplier can undertake the necessary development of advanced devices early enough to ensure their availability when the equipment manufacturer needs them.

The establishment of these close long-term relationships also implies the need for local sources of components, rather than reliance on distant sources in other countries. Apart from the physical problems of time and distance, it is inevitable that a components manufacturer developing an innovatory new device will give his local customers first access to it and those in remote countries will be last in the queue. And this effect is bound to be accentuated when, as happens notably in the case of Japanese component suppliers, the same companies also manufacture equipment and therefore are in direct competition with British equipment manufacturers.

Q10 *What factors influence decisions to invest in innovation in the UK or overseas?*
The need for a presence in or near important markets is obviously a major factor in all investment decisions, and is therefore likely to influence UK firms to invest in areas overseas such as the Pacific Basin. Continental Europe in this context should be regarded as part of the home market, rather than "overseas".

Q11 *In the light of ACOST's report Defence R&D: A National Resource, and the Government's response, is there a satisfactory relationship between the defence and civil sectors?*

In the particular case of the electronic components industry, there is not a hard and fast line between civil and military applications. There are of course some devices which are solely of military application, but many others are equally relevant to defence and non-defence markets.

Memorandum by the Electronics and Business Equipment Association

INTRODUCTION AND SUMMARY

Subject of Enquiry

To be profitable, a company must be successful in marketing, in functional design, in development, in external design for the market and in manufacture (at a cost which enables good value for money to be offered to the customer). We have taken it that the Sub-Committee's concern is with the application in a financially profitable way of new knowledge and techniques to all of these activities of manufacturing industry. We note that the Sub-Committee specifically excludes an interest in invention although invention is a sub-class of innovation and is extremely important for some types of product.

Thus we have assumed that one of the specific aims of the Sub-Committee is to examine whether manufacturing industry in the UK adequately exploits technologies, processes, manufacturing equipment and so forth, which have been imported to the companies rather than developed exclusively within them. In short, we offer our views on whether the "not invented here" syndrome is still seriously impeding British Industry. This is certainly an important question to be addressed and we trust that our views will be of assistance.

Importance of Marketing

Innovation is not enough. The successful innovative company must also have an effective marketing organisation which is able to judge accurately the likely demand for a new or innovative product and which is able to identify customers for it.

The UK Environment

The UK manufacturing environment is amongst the most mature in the world. It has patterns set in the past which may militate against innovation in some cases. The environment is comparatively highly regulated with sophisticated and strong control mechanisms. The home market is small and the industry vulnerable to small changes in external influences such as currency fluctuations. The industry is amongst the most highly taxed in the world, in spite of the apparently low rate of tax.

Again comparatively, the UK manufacturing industry, unlike all but those in North America, has not been subject to fundamental reconstruction as have others where innovation may have been seen either as a necessity or at least a valued objective. Further, the UK market has been normally freer of trade barriers than most and subject to strong overseas competition.

The EEA has shown that Corporate Taxation in the UK is among the highest in the Western world, in spite of the misleadingly low rate of tax. This is because other industrial powers provide considerable incentives for R&D and investment for their industry. The result is that in spite of higher profits, there is less retained profit for innovation and marketing than in the USA, France or West Germany. We could wish to see this situation rapidly improved in the UK, if we are to improve manufacturing.

Time-scales

By way of background to our replies to some of the questions, it is germane to note that the order of lead-time involved in bringing a new product to the various markets ranges from one to fifteen years, depending on the innovative aspect and the complexity of the product. It is essential to note that some of these time-scales are well in excess of DTI funding rules and also City expectations.

Detailed Response

Our replies to the specific questions asked are set out in the attached. "Electronic" manufacturing industry covers a wide diversity of production of goods and it is difficult to generalise. Nevertheless we have done our best to provide informative replies.

SOME IMPORTANT ISSUES

We set out here some important points to which we should like to draw attention:

Firstly, UK Government support, in other than purely the defence area where the Government is a customer, is limited to collaborative pre-competitive research and the development of standards. This is only an extremely small proportion of the work needed. Even within the limitations just mentioned, the current rules have two major disadvantages, namely:

(i) They require exploitation within a time-scale which is quite unrealistic for many markets.

(ii) They are often interpreted in such a way as to rule out support for innovative production techniques (developed on a large scale in Japan and the USA and urgently needed in the UK).

Secondly, the UK has yet to take full advantage of Community programmes. Our basic research workers have more experience than their colleagues nearer production. We need now to take a lead in those programmes, still under development, which are most directed at increasing national output. With the current Community situation, Industry cannot take such a lead without help from Government officials.

Industry also needs greater visibility of the MoD's future plans for defence procurement. This need is much accentuated by the MoD's increasing tendency to look for the cost of research programmes to be shared by Industry. Industry needs better information on which to base decisions on whether this and other costs involved in defence business represents a good investment.

Finally, we see a danger that the MoD's new arrangements for Package Management of Research could result in reduced support for the development of enabling technologies and consequently in reduced prospects of technology transfer from the defence to the civil sectors.

Q1 *What are the effects of company attitudes and structures (including personnel policies, investment decisions)?*
The UK manufacturing economy fundamentally has a low wage, low productivity basis, highly taxed, highly regulated with strong administration needs and with its performance judged almost wholly on profitability (which is not universally the case). Company attitudes lean towards tight management, strong cost control and search for stable, though not necessarily highly profitable, markets. As an example, defence was historically a good predictable market with stable, if poor returns.

Company employees usually have enormous latent innovation usually suppressed by management structures unable to permit risk in the highly competitive situation in which they operate. With its strong historical research culture and liberal arts traditions, UK scientists and engineers have achieved high technical standards. Correspondingly, UK employees are poorly trained in commercial issues such as finance, commercial law, business judgment, which personnel policies have been unable to counter. Business methods in the UK tend to be similar to those in the USA without either the cushion of a large home market or a commercial culture in its society. In contrast, Japanese methods (though benefiting from post war reconstruction) recognise their market size and culture and turn it to a virtue.

Companies widely recognised as innovative have often adopted open, university type management styles, where high value is placed on personal worth. While often successful, such style exposes the company to high risk technically, commercially and legally, but works well where a single goal or a single product type is pursued by the employees.

Q2 *How active are UK companies in seeking out external technology, especially from overseas? How well do they adapt and apply it?*
We would prefer the question to have asked "How active are UK companies in seeking out external technology, including that from overseas?"

UK companies are usually very active in seeking out information on external technology. To this end they make extensive use of the excellent abstracting services run by BCS, ICE, IEE and IOP.

UK technologists and scientists have grown up with a strong post-war research tradition of international standing. As such, in general, the engineering culture is one of technical, scientific excellence, well informed of worldwide developments.

For every problem it is normal to investigate some ten possible solutions. At this stage overseas and home grown solutions are likely to be evaluated. It is here that UK technical training, based more on scientific than on engineering or production methods, has often resulted in the adoption of a new local solution when another may already have been proven. Thus UK companies are good at seeking out external technology but they have been less good at applying it, at least in the past.

This latter situation is now changing. Advanced machining tools are now being used throughout production and are obtained from the best possible sources. Much of this at the moment is unfortunately from overseas. Many companies are providing advanced training for their production engineers using both UK and overseas sources.

Another factor for change arises from the establishment of multi-nationals in the UK who are mostly in product-line businesses. They are setting up their own technical infrastructure to achieve reliability and delivery. The strength of aviation, car and computing industries is growing through the support of companies from other countries.

However, the UK is still best known for Industries starting in a new field, rather than for established competitive industry. They should more often adopt the best available solutions and refine them, rather than always creating something new. This is a little foreign to our education system, but fundamental changes have already been implemented.

Q3 *What are the respective roles played by product development and production engineering in technological innovation?*

Product development is usually seen as a creative phase where a new design or a new standard is achieved. Production engineering is the specialist skill which translates such a design to a manufacturable item. Poor management allows a gap between the two.

The creation of a new product for sale is best recognised as having at least three elements, development, transition to manufacture, production engineering. Good management culture allows manufacturability and marketability to influence the design by setting design to cost, design for test, design for manufacture and similar targets. Production engineers bring the essential skill to achieve such targets and develop new (if needed) manufacturing processes for the new product. It is essential to good practice to draw all the skills required (development, production, marketing) together into a project team to secure a new product.

Regrettably, with the associated low status and consistent economic need to de-skill manufacturing the UK does not produce good quality production engineers in sufficient volume.

From this argument, clearly the product development skill will drive for technological innovation to satisfy the functional requirements of a product. Good production engineering should modify the innovation (increase or decrease) in line with production cost, testability, process demands, etc. Manufacture in electronics progressively reduces the labour content of production and increases the material content. The pace and methods adopted in design to achieve the balance must be strongly influenced by the production cost which should be managed by production engineering.

There is often a fourth aspect to creating a new product, to wit, serviceability and whole life costs. It would be usual to add a skill concerned with the after sales support into the development project team.

The scope for innovation is not, of course, limited to new products. In order to survive, it is necessary for Industry to find ways of reducing the costs of its existing products whilst also achieving higher quality. Production engineers need to adopt innovative methods in order to manufacture existing designs in a more cost effective manner.

Similarly, the design and development engineers need to seek innovative ways of improving existing products by the application of, for instance, new materials and components.

Q4 *How effective are the activities of Government Departments in promoting and supporting innovation?*

Direct support for innovation from Government Departments such as the DTI is limited to collaborative research programmes for which the Government provides up to 50 per cent of the funding. If academic bodies are involved they may receive full funding but in that event the funding contribution to industry is reduced.

Companies have to judge whether their own contribution of 50 per cent or more is a good investment. Some of the rules can lead to the conclusion that this is not the case.

Government policies usually involve a period of about two years for discussion followed by exploitation within five years. Thus advances in data processing, process control and aviation seldom fit in with the funding requirements for Government support schemes. In the field of information technology, the Alvey schemes were examined after two years and criticised for being too far from the market. We would not expect any results from research in IT to be visible two years after the start.

Many Government support schemes require exploitation within two years after a three-year research programme. If this is not complete the results are made available to other firms. In the process control field any equipment generated under such a scheme would still be undergoing its production and user evaluation trials when the knowledge became available to competitors.

Another rule gives the Government the right to claim its financial contribution back if a research project is not successful. As far as we are aware this rule had been implemented only once. Nevertheless, it has an inhibiting effect particularly where the research, the outcome of which is uncertain by its very nature, is less than reasonably assured of success.

Unlike the practice of many other nations, where near-market assistance or launch aid is normal, UK Government policy usually bans support of near-market research. Furthermore, this policy has been interpreted in such a way as to rule out much of the research on production techniques on the grounds that "production" is "near-market". In fact, some research on production techniques may bear fruit only after 10 years or more. Innovation in efficent production techniques is carried out on a large scale in Japan and the USA and is urgently needed also in the UK.

More generally a change in the rules to provide effective Government support for longer-term innovative projects is essential. If this is not done, the UK will lose out to other nations whose Governments are more supportive of their industries.

We have recently sought to open up a dialogue on such policy matters with officials in the DTI and we hope that we shall be able to discuss the above and other issues with them.

The MoD has until recently taken on the responsibility of ensuring all aspects of its needs, research, development of enabling technologies, funding of development and, of course, purchasing production. Against this background, we believe that the UK defence industry has been exemplary in its standards of innovation, especially so in view of its small home market.

There is a concern now, however, that the MoD's concepts for increasing the level of competition in defence contracts will also affect the willingness and capability of companies to adopt innovative solutions. Companies with strong and active R&D programmes will inevitably have higher overheads than those which concentrate on a "make to print" function. This is likely to result in these "make to print" organisations being able to offer lower prices for follow-on production contracts. Over concentration on price as the criterion for supplier selection could result in a reduction of the funding available within companies for innovative R&D work.

We understand that the MoD intends to continue to provide active support for the development of the enabling technologies related specifically to future defence capabilities. We have some concern about possible adverse effects on this support which might result from the MoD's new arrangements for the management of its research programme; we have expressed these concerns in our response to Question 11. Here we would draw attention to the MoD's increasing tendency to look for the costs of research programmes to be shared by Industry. As in the civil case, companies must make a judgment on the value of their investment. For this reason (and on account of other costs which Industry may incur) Industry has long sought to have greater visibility of the MoD's future plans for defence procurement. There has been some limited response from the MoD but not nearly enough.

Finally, we would draw attention to some important differences between the UK and some other nations. Much of the rest of the world has either large home markets on which economies of scale free up investment for innovation or promotion of manufacturing industry is seen as a strong plank of national policy. Whilst we all have aversion to the danger of promoting inefficiency, international contracts require UK Industry to be fiercely competitive and often engender a tight cost control culture with low investment attitudes.

Q5 *What are the effects of City attitudes to investment in innovation?*

The general perception in Industry is that the City's attitudes are not conducive to investment in innovation. The City is regarded as being averse to risk, as being driven by considerations of short-term profit, as having a vested interest in the movement of investment funds from one stock to another and as motivating shareholders to expect consistently high returns. On this view, the City fails to understand long-term gestation times and regards R&D as a cost and not an investment.

City attitudes are essentially based on share value growth over a short period of time. In the aerospace industry, product development investments may take many years to come to fruition which cuts little ice with institutional investors reviewing their portfolio every quarter. Again in comparison, the post-war reconstruction economies tend to place more emphasis on company growth rates, business achievements and, in some cases, attitudes of the state than profit in assessing company worth. In the UK environment, capital investment, innovation and research, whilst essential for the continued health of a manufacturing industry, tend to be regarded as avoidable cost which must be minimised to give sufficient profit for distribution or as a buffer against external vagaries.

We have no doubt that the general perception as described in the previous paragraphs contains some of the truth but not all of the truth. It may well be that companies could take more trouble to sell innovative ideas to the City with the backing of a good business plan.

There will always be difficulties in doing this with longer range or exploratory research where the risks are high but the fruits of success could be outstanding. This is because of the difficulty of making predictions in situations of this kind.

We understand that BP is attempting to evaluate and to prophesy the value of research by a methodology similar to that used for any capital investment. The historical results show the undoubted value of innovative R&D but as yet there is little confidence in the methodology when applied to the longer term research.

Q6 *What is the effect of the legislative and regulatory framework concerning for example labour costs, patent laws and tax concessions on R&D and the purchase of know-how?*

The UK runs a mature economy backed by an exacting regulatory process. It does not benefit from either Government support for innovation or a big home market in which economic production opportunities would encourage innovation.

Patent law is being harmonised within Europe and indeed throughout the world, and therefore offers no particular advantage or disadvantage in the UK.

The taxation system pertaining to R&D is unclear in its rules and uncertain in its administrative methods. Whilst tax allowances exist at 100 per cent on capital for scientific research and on written off revenue cost of R&D, most companies find legitimate claims result in long and exhaustive justification through several levels of the Inland Revenue. The cost and time to support claims generally is disproportionate to the value and leads to unclaimed benefits. R&D costs, whether incurred in-house or for purchased know-how, can be capitalised in which case the allowance is 25 per cent of written down value but again requires exhaustive justification. The importance is not necessarily the absolute value of the taxation allowances but the general uncompetitive position created in comparison with other economies.

Q7 *How effective are the mechanisms for technology transfer from HEIs, Research Councils and public laboratories to manufacturing industry?*

Our public laboratories have many industrial clubs and we would cite those of the Flow Measurement Club of NEL, the Optical Measurements Scheme of NPL, the Sensors Club of the Laboratory of the Government Chemist and the outstanding industrial linkage provided by NAMAS.

RSRE and the other defence establishments have many contacts with defence firms and they collaborate with DTE to try to make their knowledge available to industrialists. We very much hope that this situation will continue with the advent of the Defence Research Agency though we have some fears that, as a result of commercial pressures being placed on the DRA, it might not do so.

The various research councils now involve industrialists on all their research panels, often to the tune of 50 per cent. The level of co-operation with the industry has increased to the extent that there is some slight worry that long-term academic research could suffer unduly.

Thus there are some mechanisms in place for technology transfer from HEIs, Research Councils and public laboratories to manufacturing industry. There is nevertheless room for improvement. We have ourselves opened a dialogue with the Science and Engineering Research Council with this in mind.

Technology transfer into manufacturing normally involves the recipient protecting the resultant know-how and hence restricting the provider of the intellectual property. HEIs and public laboratories have often found that difficult to accept.

Q8 *Does the UK benefit sufficiently from EC support for innovation? How might it be improved?*

EC collaborative research programmes are regarded by Industry as having been aimed at improving the technological capabilities across the breadth of the community. In this they are considered as having been successful, and fundamental pre-competitive programmes such as Esprit have started to create a broad European technological power-base. British companies involved in such programmes as Esprit, Brite-Euram and Prometheus are generally considered to have gained by their involvement, particularly where EC funding has enabled research to be undertaken which might not otherwise have been afforded.

Two reservations have been voiced. Many EC programmes involve the participation of partner companies from the smaller nations in order to secure their political support and companies in these countries are likely to enjoy a kinder national environment for the exploitation of the evolved technologies than is the case in UK.

The same factor leads also to higher management costs in relation to technical contributions which substantially reduce the funds available to the research activities.

Furthermore, it is inevitable that any international collaborative programme will result in a draining of know-how from those nations whose industries are at the forefront of a particular technology into the partners with less developed industries. This may well be welcome for its political benefits, but in certain areas such as aerospace and telecommunications, it has been costly to the UK Industry's commercial strength and the nation's balance of payments position.

EC funding has hitherto been targeted largely on early research. Looking to the future, there is a need to strengthen nearer-market programmes such as Eureka. This will provide support for the general design of innovative products and manufacturing processes and provide for their demonstration as applications of the new technologies.

This will be an extension of the pre-competitive stage, which will bring Industry nearer to the point where it can embark on the development and marketing of specific new products and process equipments deriving from the innovations.

The EC are aware of this and in such areas as IT they are endeavouring to steer their funding accordingly while ensuring that the activities are still of a pre-competitive nature.

A matter of current concern is that of time-scales. To ensure that the maximum benefit is achieved from the innovations arising from research programmes, in terms of sales of products in the marketplace, it is important to have an appreciation at the outset of the time at which the product must hit the market, and to envisage from the start when the different stages from research to production must take place. The method of support for the research and early design phases must be planned to enable this timetable to be met, for our Japanese and US competitors will be set on similar dates. Virtually all EC programmes are tailored to a conventional time schedule, for example, three years' research, a two year pause for consideration, a three year follow up programme followed by two years development into full production. The programmes need to be much more flexible in order to target realistically the "window of opportunity".

Q9 *What are the effects of the varying relationships between companies and their suppliers?*
The traditional relationships of arm's length, lowest price trading, do not generate an innovative climate. The main drawback with this approach is that it frequently leads to a large base with many small suppliers. Resources are usually not sufficient to build up more than a formal relationship with each supplier and the small suppliers do not have the resources for innovation. This disadvantage is brought home when retrenchment to core businesses as a response to competition demands greater dependence on supplier innovation to provide the compensating competitive edge.

Recognising this, many companies, particularly some of the larger companies, are tending to reduce the number of competitive suppliers, to fewer preferred suppliers with long-term, and sometimes risk sharing, contracts. Establishment of long-term contracts with strategic suppliers can lead to technology transfer in both directions which generates mutual confidence and sound relationships.

The large and diverse capability of UK industry to satisfy its primary supplier needs is one of the country's strengths. Whilst the rationalisation of suppliers may weaken this, the evolvement of a tiered supply system with strong links to immediate sub-contractors at all levels would reduce the damage, encourage competitiveness between groups and encourage supplier innovation.

Of course, some "user" companies will choose to take a strong and direct influence in the development of the components and sub-systems which they wish to procure. This will be particularly necessary in cases where the technical specifications are either very demanding, or unique to that industry. If the nature of these components and sub-systems requires specialist techniques to incorporate and integrate them into the large scale products of the "user" company, then such a close association with the supplier will be especially important.

Other companies may choose to distance themselves from the suppliers; preferring to be an intelligent customer, but also who lets competition between suppliers predominate. This may be more appropriate in situations where the technology in the manufacturing process is somewhat independent of the technology in the supplied components and sub-systems.

All shades exist between these two scenarios, and it would be inappropriate to expect a single policy to apply successfully across all cases.

The perception of innovation can be different for customers and suppliers. A "user" company is likely to see innovation in its own organisation as a strength but innovation in its suppliers as a risk.

Supplier selection criteria can also inhibit innovation. An undue emphasis on product cost in the selection process can result in greatly reduced profit margins with a resultant reduction in the capital available to fund research into innovative designs and production methods.

Q10 *What factors influence decisions to invest in innovation in the UK or overseas?*
Factors which favour investment in the UK include the following:

(i) High availability of creative and innovative researchers from the universities and educational establishments.
(ii) Much lower cost of carrying out research in the UK where salaries are low.
(iii) The UK has a diverse manufacturing industry where skills, facilities and services are readily obtained.
(iv) In some cases, good support is available such as, for example, the Scottish Development Agency.
(v) Easy access to the source of innovation, not only in the initial stages of the activity but also during its life cycle.
(vi) Greater assurance that long-term access to the source of innovation will not be disrupted by factors outside the control of those making the investment.
(vii) The UK is a good market for testing the acceptability of new product concepts, particularly for consumer products.
(viii) The UK has strong trading links worldwide and excellent communications so that export of the results of innovation can be readily achieved.

Some unfavourable factors are as follows:

(i) Government support of R&D in overseas countries may be easier to obtain.
(ii) In support of foreign sales the host country may have offset requirements which usually are designed to encourage in-country R&D or technology transfer.
(iii) Relative tax benefits or penalties will also influence the decision as to where investment could be placed.

There is a view in some quarters that the UK costs of manufacturing and quality of manufactured products are much worse than those of overseas competitors. While this may have been a legitimate view at one time we believe that it is becoming less and less true now

It is noteworthy that Japanese and American companies such as Sony and Digital are investing rapidly in manufacturing capacity in the UK and are also setting up research laboratories here.

Q11 *In the light of ACOST's report "Defence R&D: A National Resource" and the Government's response, is there a satisfactory relationship between the Defence and Civil sectors?*
It would be a large undertaking to answer this question comprehensively. We confine ourselves therefore to three main points.

Firstly, we refer to the Government's comment that in defence applications "use is made of technologies developed in the civil sector . . . wherever possible". This is certainly so in the case of information technology, and the increasing extent to which this is happening should, in our view, be a matter for satisfaction. The same is true of the advances made in the civil use of fibre-optics, digital radio and telecommunications. Also the semi-conductor devices and CAD equipment developed for civil purposes find their application in the defence industry.

Our second comment relates to the MoD's new arrangement called Package Management, for the direction and management of defence research. This arrangement is a manifestation of the "tauter and more precise customer/contractor relationship" referred to in the Government's reply to ACOST. Under this arrangement, all defence research has to be clearly related to one or other of a number of Key Military Functions. We do not disagree with this concept; indeed we applaud it. We understand, however, that all the research on enabling technologies is divided up into small parcels which are distributed widely among the Research Packages which are themselves identified exclusively in terms of military applications. Our fear is that a coherent view and hence coherent direction of the more basic defence research may be lost with serious consequences for progress in the development of enabling technologies. This would have serious consequences in turn for the country's defence capabilities in the longer term. It would also reduce the scope for spin-off from defence into the civil sector since it is in the enabling technologies that this is most likely to occur.

Often the drivers in business, e.g., quality requirements, qualification processes, standards, etc., pose barriers to relationships at all but the enabling technology level. Where compatible civil and military business exists, however, there is also a strong flow of technology between the two at the system or sub-system level; examples are air traffic control and aircraft design.

Memorandum by the Engineering Council

1. The UK's background climate restricts investment decisions by companies. More emphasis on long-term needs is required. Innovation must be stimulated not only in industry but in education and training.

2. While large UK firms do seek out and apply external technology, small- and medium-sized firms are less aware of the opportunities.

3. Innovation should be applied from the research stage to manufacture. New techniques are not understood at board level in all companies.

4. Government is not giving a policy lead in key long-term technical areas. Support is not aligned to the need for innovation at the near-product stage. Bureaucratic procedures need to be streamlined, especially for small firms.

5. The City seems to discourage investment in innovation. Too much emphasis on the short-term. Could large companies do more to finance innovation?

6. The legislative and regulatory framework needs to be reviewed.

7. Mechanisms for transferring technology from HEIs, Research Councils and public laboratories are improving, but more needs to be, and can be, done to help the process.

8. Large companies often do benefit from EC support for innovation, but it is a problem area for many medium- and small-sized companies.

9. Relationships between companies and suppliers need to be more constructive.

10. A common criteria is a short-term pay back on investment. Longer term planning and better marketing needed.

The Engineering Council, an independent body, has 300,000 Chartered Engineers, Incorporated Engineers and Engineering Technicians on its register. It also has 300 organisations, all employers of engineers, affiliated to it. The Council sets the standards for the education, training and experience of engineers and technicians leading to the awards of its three titles.

This paper was prepared after consultation with leading affiliated employers of engineers.

Q1 *What are the effects of company attitudes and structures (including personnel policies, investment decisions)?*
Attitudes to innovation are very much influenced by the company culture, but other factors like market and economic conditions together with the investment requirements of shareholders, notably the City, are fundamental in determining whether positive attitudes towards innovation can prosper. These factors have all tended to work against investment in innovation in the UK. Instead the emphasis has been on short-term financial objectives. This has been reinforced by the inherent lack of regard, in UK society, for those involved in technical and innovative work. In general the UK's background climate is thus less favourable than that in many European countries or in the USA and Japan, where attitudes and financial structures are often more supportive towards investment and innovation and greater emphasis and recognition is given to long-term benefits. Nevertheless, there has been an improvement in the UK's background climate, in the greater emphasis given by industry to strategic planning of long-term competitiveness and technology requirements and in the structure of industry itself. In the latter there has been a shift from traditional hierarchical structures, towards organic or cellular structures and a greater tendency towards enterprise and reward-based personnel policies. Whether improved strategies and structures are evident across the whole of industry seems, however, to be open to question and, while some companies have good track records on innovation, it is by no means apparent that innovation, as defined for the purposes of the Select Committee, is discussed or followed up at board level in industry as a whole. In such companies it is unlikely that the stimulus for innovative change will come from the board room.

Long-term improvements in attitudes towards enterprise and innovation need to be nurtured and developed in education, in training and then maintained through career long continuing education and training. Encouraging work is already being done in many schools and in certain areas of higher education but it will need to be sustained and developed further if it is to have a genuine impact. Continuing education and training needs to become an accepted necessity in industry, supported by personnel policies which encourage professional growth, and reward performance and technical achievement. The Engineering Council and others are already very active in promoting the above and, in general, the government has been very supportive of these efforts. Much of the onus, therefore, rests with industry itself.

Q2 *How effective are UK companies in seeking out external technology, especially from overseas? How well do they adapt and apply it?*
In the larger companies there is now a much greater emphasis on strategic planning to assess long-term competitiveness, technology requirements and product needs. This is, however, often constrained by short-term financial needs.

Of The Engineering Council Industry Affilitates surveyed on this question it was apparent that those involved in the most internationally competitive areas of engineering, e.g., aero-engines, were the most likely to make successful use of overseas technology. In companies with less experience and knowledge of overseas markets and competition, particularly small- and medium-sized companies, there is generally less awareness of the opportunities, and dangers, technological progress overseas provides.

The acquisition of external technology is not always the cheapest solution and licensing is not an alternative to having sufficient qualified staff in place to carry through innovation "in-house" and usually leaves the licensee unable to adapt the technology or apply it to best advantage. Licensees are thus in a position of weakness rather than strength.

Q3 *What are the respective roles played by product development and production engineering in technological innovation?*
Product development and production engineering are interdependent although they have historically tended to be carried out as separate activities. Indeed, many innovative product designs have failed because they failed to meet the market requirements of function, durability and quality at minimum cost. Meeting these needs requires that the process should start at the research phase, continue during product development and continue with production engineering seeking innovative and better ways to manufacture those products which are already in production.

There now appears to be a more widespread appreciation of the link between product development and engineering production, although there seems to be a question-mark against the extent to which new techniques like "Just in Time", Total Quality Management and CAD/CAM are fully understood by the decision makers within companies and integrated into companies' philosophies.

Q4 *How effective are the activities of Government departments in promoting and supporting innovation?*
There is a conspicuous failure on the part of Government to provide long-term technical policy in key areas like energy conservation and environmental matters together with manufacturing technology. This has led to uncertainty for industry and consequent lack of investment. Recently the Government seems to have almost completely abandoned the provision of financial support for innovation. Insofar as support is available it has become such a bureaucratic maze and art form that only the larger companies, who are able to devote the time and effort necessary, can benefit from it. There is also a problem with the sort of support

that is available. In general, Government departments are providing support to fundamental research with emphasis on market need. This overlooks the fact that innovation generally occurs in the later stages of near-product development. That area, where short-term business pressures are most likely to act as a restraint, is poorly served by the support presently available. Other countries, particularly Japan, through MITI, have been more successful in encouraging innovation through national policies.

For the smaller firms a quick response from Government is often vital and more could and should be done, particularly for small firms, to minimise the bureaucratic procedures which are presently hampering them. The Government should actively seek means to provide greater stimulation and support to small- and medium-sized firms. It should also seek to make better use of the information (on new knowledge and techniques together with market trends) channels open to it, particularly the commercial departments of UK embassies overseas. At present such efforts are sometimes amateurish and hindered by the constant changes of personnel and loss of expertise.

Q5 *What are the effects of City attitudes to investment in innovation?*
The City's attitudes and responses have little, if any, positive influence on the application of new knowledge and techniques. On the contrary, the City seems to positively discourage investment in innovation. While it likes to see adequate research and development, it does not like it to be at the expense of current profit growth, although a well-explained shortfall may sometimes be acceptable for one year. Shortfalls, however, make companies vulnerable to predators from home and abroad. The City thus acts as "the master" instead of "the servant" of industry, with the emphasis firmly on short-term return, and seems unprepared to finance innovation technologies which may take years to reach fruition and a particular reluctance in the case of "green field" starts. The problems this creates have recently been exacerbated by the high cost of capital. The only clear exception to the above is Venture Capital, which makes longer-term investment and is prepared to undertake high risk, technologically based investments where correspondingly high rewards are possible. However a large proportion of these are directed towards management buy-outs and buy-ins, where innovation in company policy and organisation takes precedence over technological innovation. In addition a number of funds set up specifically to invest in small enterpreneurial companies fail to act as a stimulus because they set the investment hurdles too high. A further disadvantage of the Venture Capital approach is the high probability that innovations will be sold off at the end of the investment period to gain the "quickest return" possible.

There are some circumstances in which the small- to medium-sized private firm may, if funding can be obtained, take a longer-term view on innovation than those responsible to shareholders. One of the small companies affiliated to The Engineering Council believes it could not have developed and followed through on innovation to the same extent if it had been a public company. That company noted that a slightly larger subsidary of a large UK engineering group had to demonstrate a 30 per cent return on investment from year one to obtain capital funds for new activities or equipment. On the other hand, the reluctance of banks to back innovation and current high interest rates acts as a considerable restraint to most small firms.

It is ironic that while the city has such negative attitudes towards long-termism and innovation by UK firms, it is altogether more positive in supporting Japanese and other foreign companies, whose modest returns reflect their significant and continuing investment in innovative technology. Perhaps part of the solution might be for large, financially strong companies, to be encouraged to take over the role of the City in making finance available to innovative companies, accepting both the risks and the business synergies.

Q6 *What is the effect of the legislative and regulatory framework concerning for example labour costs, patent laws and tax concessions on R&D and the purchase of know-how?*
The encouragement of industry to carry out innovation should be a requirement of the legislative and regulatory framework. At present the balance in the UK does not achieve this. Governments instead have tended to offer palliatives in the form of short-term initiatives, whose scope and success is usually very limited. The whole of the legislative and regulatory framework should be reviewed with the aim of improving the possibilities for innovation.

Q7 *How effective are the mechanisms for technology transfer from HEIs, Research Councils and public laboratories to manufacturing industry?*
The mechanisms for technology transfer from HEIs, Research Councils and public laboratories to manufacturing industry do appear to be improving as they are eased and simplified. The development of Science Parks has also been particularly helpful. However, it remains difficult for companies, especially smaller companies, to find out what technology is available from the many available sources. This is particularly the case with regard to defence establishments where a natural combination of security restrictions and resources make publication and dissemination of the information difficult.

The primary task of HEIs is to prepare well educated people for industry through undergraduate teaching and post graduate research. To meet the needs of industry, HEI staff must be up to date with those needs and this can be achieved by HEI staff undertaking consultancy work. The significant benefits that could be achieved by such a relationship should be encouraged, perhaps through the provision of financial incentives and support to industry to sponsor academic research. A further effective way of transferring knowledge would be greater transfer of people between research centres and industry.

Q8 *Does the UK benefit sufficiently from EC support for innovation? How might it be improved?*
The EC support programmes for support of innovation tend to be directed towards specific strategies and are unsatisfactory in that they usually relate to pre-competitive research and development which has little or no direct contribution to the process of innovation in industry. If the EC is to strengthen its manufacturing base, it should provide a framework for direct funding during the innovative phase of the product development cycle and the supporting manufacturing technology.

Larger companies tend to have a reasonably satisfactory record of participation in EC programmes, given good teaming arrangements and sound, well-reasoned proposals. The processes are bureaucratic but workable given the will of the participating companies. The trick is to identify programmes which are relevant to a company and where the contribution to the company programme can be achieved while minimising the extra work packages necessary to meet the EC programme.

For the reasons outlined above, EC support tends to be a mystery to most small and many medium sized firms.

Q9 *What are the effects of the varying relationships between companies and their suppliers?*
Relationships between companies and suppliers in the UK have tended to be too adversarial. Total Quality Management calls for "partnerships" between these parties and that they should work towards common goals and better performance in the round. It also requires that suppliers should continually innovate to achieve the highest possible standards at a commercial price. This in turn can benefit suppliers directly in their improved ability to tender for overseas work.

Q10 *What factors influence decisions to invest in innovation in the UK or overseas?*

The main factors which influence decisions to invest in innovation are perceived market opportunity and cost benefit. A common criteria in the UK is a two or three year payback on investment. This is usually far too short for innovation to take place. Without doubt there are examples in the past where innovation has been entered into for purely technical interest. More often it has been to fight off competition or maintain market share. While that is valid and indeed essential, it is regrettable that industry has not paid more attention to the creation of frameworks which seek to develop pro-active capacity for future wealth creation, new business growth and growth in areas of existing skills and experience. A further area in which UK performance could undoubtedly be improved is the use of feedback from marketing to provide sound information for investment decisions.

Memorandum by the Engineering Employers' Federation

Obstacles to innovation and the conditions which stimulate innovation

INTRODUCTION

1. The Engineering Employers' Federation emphasises strongly the importance of *marketing and production* in the process of innovation. The UK has traditionally been competent in generating ideas and in the early technical development of those ideas.

2. Near-market technical and commercial development, marketing and production engineering are also vital to successful innovation. These functions are highly resource-intensive, being very substantially more expensive than initial research and early development. This submission is directed primarily at ways to improve our performance in these functions.

Key areas

3. We focus on education and training; and the financial and fiscal environment for investment. We believe that in both of these areas there are serious obstacles to innovation in manufacturing and that action can and must be taken to replace those obstacles with conditions which stimulate innovation.

4. Our comments on education and training relate generally to obstacles to innovation and to the stimulation of innovation, rather than to any one of your 11 particular questions. Our comments on the financial and fiscal environment relate partly to your question 5 ("What are the effects of City attitudes to investment in innovation?"); but also concern government policy.

SUMMARY

5. Innovation in the manufacturing industries is an essential driving force in economic development. Despite the success of some individual UK companies, there are serious deficiencies in the UK's ability to generate manufacturing innovation on a sufficient scale.

6. We emphasise especially the crucial importance of education and training and of an adequate and supportive financial and fiscal environment.

7. We recognise that there are already moves to improve education and training; but these need to be reinforced and increased. The penalty for failure here would be permanent economic and social decline for the whole nation.

8. The financial environment is a more controversial issue, as there are many UK firms which thrive in the existing climate and perceive no problem here. But others are concerned that there are too few such successful firms and that financial conditions really are inhibiting innovation.

9. We urge an early and penetrating re-examination, without prejudice, of the frequent and persistent allegations, that "short-termism" in financial markets inhibits innovation. As this submission is finalised we have received a press report that the Department of Trade and Industry is reviewing this issue. If those reports are true, we welcome the DTI's action.

10. Previous enquiries have not resolved the issue of "short-termism". If the allegations are true, then the causes must be identified and rectified. If they are not true then this needs to be firmly established so that attention can be directed to matters which are important instead of being diverted to "short-termism".

11. Although nominal rates of corporate taxation are relatively low in the UK, the absence of inflation adjustment in the assessment of taxable profits means that the effective tax rate exeeds the nominal rate. The tax treatment of fixed investment expenditure penalises investment even when inflation is low or absent —and increasingly so when inflation rises.

12. We urge that full tax relief be given for fixed investment expenditure, including capitalised R&D expenses, at the time the expense is incurred.

CRITICAL DANGERS FOR THE UK ECONOMY

13. The future prosperity and growth of the whole UK economy depend critically on the performance of the manufacturing sector.

14. Industry can afford innovation only if it can exploit commercially the resulting technology.

15. Successful development of new technology is expensive. Industry will transfer expensively-developed technology to other businesses only where there is adequate recompense for the high development costs incurred.

16. In many cases, financial targets for UK enterprises are more safely and certainly achieved not by investing in high-risk innovation projects but by importing products and often the associated manufacturing technology from companies based in countries such as Japan and West Germany which have significantly different attitudes to risk investment and return on capital.

17. The main factors which influence decisions to invest in innovation in the UK or overseas are thought to be:

— Availability of people—at all levels—with the necessary skills, attitudes and experience.
— Interest rates and the financial and fiscal environment.
— The existence of appropriate facilities; and
— Identification with centres of excellence in specific fields.

18. The EEF indentifies two areas where public attitudes and government policies are critical to innovation. These are:

— Education and training; and
— The financial and fiscal environment for investment.

EDUCATION AND TRAINING

19. Innovation in manufacturing industry and our international competitiveness depend critically on a first-class education system.

20. Successful innovation now more than ever depends on drawing on the brainpower of all employees. Education must establish in all young people a learning culture and a readiness to initiate as well as to accept continuous change.

21. Formal education should sustain and reinforce children's innate investigative, creative and managerial abilities and competitive spirit.

School education

22. The pursuit of excellence must start in schools.

23. The National Curriculum is a significant step in the right direction. Implementation of the defined objectives will be difficult for many teachers. When these are met, the targets will need to be raised.

24. It is particularly important that Technology should be established in the National Curriculum for all children, throughout statutory schooling. This must be made into a high status subject, well underpinned

by mathematics and science, and attractive to the most able children. Technology, as outlined by Lady Parkes' Working Party, offers particular opportunities to develop three-dimensional conceptualisation, practical creativity, investigative, problem-solving, planning and evaluative skills and teamwork.

25. The teacher-training requirement is daunting. We believe that a major resource input will be needed to ensure that teachers are capable of implementing the welcome changes in government education policy. Teachers will need training particularly in how to make optimum use of others' expertise, including colleagues and occasional/part-time "teachers" from industry—such as "neighbourhood engineers".

26. It would be helpful if more schools could run the type of school/industry projects encouraged by the SATRO (Science and Technology Regional Organisation) "Learning from Industry" scheme.

27. Relevant skills and attitudes should also be developed to a greater extent through science classes at primary and secondary levels. There should be more emphasis on open-ended experiments.

28. Standards of achievement in mathematics must be raised progressively, at least to the levels achieved in competitor nations.

29. The brighter pupils with an interest in languages should not be permitted to spend less than 20 per cent of their time on science and 10 per cent on technology during the final two years of statutory schooling, as the Government currently allows.

30. Economic awareness needs fostering in schools, particularly in Technology classes, using industrial examples.

31. A broader and more balanced education is also required in school sixth forms, with more emphasis on the development of skills (e.g., problem-solving and communications skills).

Higher education

32. Not only school education but also higher education is critical for the stimulation of innovation.

33. We support the Training Agency's "Enterprise in Higher Education" initiative and would like to see it extended to more institutions.

34. The Manufacturing Systems Engineering Programme was a welcome attempt to upgrade the status and content of production engineering degree courses.

35. The expansion of multi-disciplinary engineering degree courses will broaden design and development engineers' understanding of systems, manufacturing and resource management; and thereby contribute to their ability to integrate design and development with manufacturing and commercial considerations.

36. We hope that these broader courses—and later Technology in schools—will help us to attract more high-quality applicants for engineering degree courses. Our demand for engineering graduates continues to outpace the supply.

37. Recruitment of an adequate technician support base is even more worrying. Our industry's most alarming skills gap is at the higher technician/upper supervisory level. This is a a long-standing problem, which is reaching serious proportions as existing employees reach retirement age. It has arisen mainly due to social pressures for potential middle managers to seek a university education, but also to the hiatus in educational provision following the creation of BEC and TEC and subsequently BTEC and, in engineering occupations, the virtual closure of the technician route to chartered status. Some of the graduates we have recruited would have been better suited to technician engineer development programmes and roles.

38. Our inability to recruit sufficient technicians has hindered innovation and led to inefficiencies in graduate utilisation, which, in turn, have affected graduate recruitment and retention.

39. We support the case being made for expanding higher education provision. The expansion should be primarily at higher certificate/diploma level and in the provision of post-experience short courses. At Honours degree level, a further switch towards engineering programmes is needed, so that we can use engineering graduates to a far greater extent in commercial functions, as well as in engineering functions.

Post-graduate education and training

40. Post-graduate education (MSC programmes) should be modularised, so that employees' expertise can be developed progressively and selectively in managerial, as well as technical areas. Transferable credits towards recognised qualifications should be widely available, to motivate individuals to develop their knowledge and skills.

41. There is inevitably a time lag between the development of new technologies and techniques and their inclusion in education and training programmes. This is exacerbated by employers' difficulty in identifying relevant updating programmes. The time lag must be minimised.

42. More cross-fertilisation is required between higher education and industry, to keep academic staff up to date, to influence undergraduate education and to assist technology transfer. The "Teaching Company" scheme is particularly worthy of further development. The Alvey and Eureka programmes have also been helpful in a limited way.

THE FINANCIAL AND FISCAL ENVIRONMENT FOR INVESTMENT

City attitudes and "short-termism"

43. City attitudes are driven largely by the environment in which the City works. A conventional view is that investor expectations in the UK—and also in the United States—are thought generally to require higher returns, lower perceived risks (a "track record" is required) and earlier pay back than in some other countries such as West Germany or Japan. Therefore investments in innovative, potentially high growth fields tend to be regarded as unattractive in the UK investment climate.

44. Levels of fixed investment in UK manufacturing have tended to be lower, measured per employee or in relation to sales turnover, than in the same industry sectors of leading competitor countries.

45. The attitudes to investment and risk held by the UK financial community are perhaps rational in their particular environment. It is beyond reasonable belief that "short-termism" arises from the *deliberate* refusal by investors to finance projects which they would regard as worthwhile in the long term. If attitudes are wrong, then something in the environment is wrong.

46. There are many successful UK engineering firms which thrive in the existing climate and do not regard the financial environment as an obstacle to innovation. However, there are others—including some successful firms—who do perceive an obstacle in the "short-termism" of the financial environment in the UK. Financial investors in Germany and Japan are said to be more prepared to accept technological and business risk, and more prepared to invest for many years without current returns, than investors in the UK (or the United States).

47. This controversy as to whether or not "short-termism" is a serious obstacle to manufacturing innovation in the UK is at best a debilitating diversion of energies from more important matters. If the allegations are true, then this is a major problem which must be resolved before the UK economy can fully prosper in the post-North Sea oil conditions of the 1990s.

48. We urge an early and penetrating re-examination, without prejudice, of the frequent and persistent allegations that "short-termism" in financial markets inhibits innovation.

49. As this submission is finalised we have received a press report that the Department of Trade and Industry is reviewing this issue. If those reports are true, we welcome the DTI's action.

Tax treatment of companies' investment expenditure

50 One obstacle which can be identified in the fiscal environment is the tax treatment of investment. Since the withdrawal of "100 per cent capital allowances", UK firms have been unable to obtain full tax relief for plant and machinery investment at the time the expense is incurred. Tax relief is deferred, with the effect that the investing company loses the value of the interest foregone on the unrelieved tax. At times of high inflation, this loss becomes greater. Full tax relief is given for research and development expenses, but only if they are written off immediately in the accounts—although these expenditures are generally in the nature of an investment. If R&D expenses are capitalised, they are penalised by the tax system in the same way as plant and machinery investment.

51. Allowance of full tax relief for fixed investment and for capitalised R&D expenses would be a helpful forward step.

30 *April* 1990

Letter from the Federation of British Electrotechnical and Allied Manufacturers' Associations

Thank you for your letter of 30 January which we decided to take deep into our system in an effort to identify our considered reply.

Initially, may we state that the BEAMA Federation has 19 member associations, and some 560 member companies. It is the major grouping in the British electrotechnical manufacturing sector, covering 50 per cent of annual turnover of that sector. This turnover is £33,322 million, of which £15,990 million relates to the BEAMA product range. Some 40 per cent of the BEAMA sectors' turnover is exported, and until recently, the sector always made a positive contribution to the Balance of Trade.

From the response of our companies, it is clear that innovation in manufacturing industry is divided into two parts. The first part is the equipment and systems installed on the shopfloor to manufacture the products which they will market; the second part is the introduction of new technology into the marketed products themselves. The two aspects are not synonymous, as we trust, our answers will demonstrate.

The adoption of external technology in some small-sized companies is likely to be the norm, as they do not have finance or staff to devote the time to seek out new technologies either at home or overseas. The survey undertaken by BEAMA some years ago, indicated that a figure of less than 2.5 per cent of gross turnover of all UK companies was invested in research and new technologies and worryingly, in the case of small firms none at all.

The City attitudes are not seen as helpful and that of DTI rather selective as is the European Commission.

Companies in many instances are struggling under present constraints of funding and taxation to stay in business in the short to medium term.

Q1 *What are the effects of company attitudes and structures (including personnel policies and investment decisions)?*

A. (a) *Attitudes*

Company attitudes which have strong bearing on whether innovative projects are undertaken include:

(i) Expectation that projects will give a return from commercial exploitation within three years of initiating development.
(ii) investment on innovative projects must be considered in competition with all other product or process development opportunities; and
(iii) Market led, rather than technically led initiatives tend to be preferred.

Innovation for its own sake is very rarely justifiable. For innovation to be undertaken, it must offer:

— The possibility of realising a conceived novel product at an acceptable marketable price within a year or two time-scale.
— Significant cost effective enhancement to the performance of existing product; or
— Cost reduction in operations.

Since companies in general have many options for new product development, the prevalent attitudes tend to result in those options being favoured which are based on established known technologies where the risks are clearly identifiable.

(b) *Structures*

Management structures, based on an architecture of line management, tend to be conservative, slow in response and unresponsive to innovation. Many companies, however, are responding to the messages of management gurus to create structures more suited to encouraging initiative and enterprise which are vital to the success of innovation. Smaller companies, although limited in funds, are more responsive. The further creation of smaller companies could significantly change the national performance in innovation.

Successful innovation is invariably achieved by the initiative and drive of individuals. Changing management structures to encourage entrepreneurship should assist innovation.

Beyond these generalities, the degree to which automation is introduced on the shopfloor will be determined by the size of the company. Automation islands are common with a perceived improvement and efficiency/time/financial return can be observed but full automation will remain the prerogative of large companies.

We can expect to see increasing introduction of CAD/CAM within drawing offices and machine shops which will introduce CNC machine tools with direct numerical control. We can expect to see some further introduction in certain functions on the shopfloor of robotics (e.g., for welding) but the degree of implementation will be the employment of appropriate qualified staff and that in turn will be governed by the financial decision of the company and the effect on them where appropriate of the City.

Q2 *How active are UK companies in seeking out external technology, especially from overseas? How well do they adapt and apply it?*

A. It is difficult to generalise on all manufacturing companies. Some small companies (e.g., university, campus companies) with limited R&D effort are very dependent on exploiting licensed technology. In general, however, UK industry has sought internally to find new ideas and has been slow to respond to external opportunities, largely because the risks are more clearly understood in internal projects.

Effective exploitation of acquired technology is greatly assisted by proximity to the source and by the collaboration necessary between the parties during the engineering phase. This strongly favours relationships that are geographically close. Difficulties of travel and dialogue, including different languages, limit the adoption of overseas opportunities.

Q3 *What are the respective roles played by product development and production engineering in technological innovation?*

A. Product innovation tends to be led by product development. Innovative technology in manufacture may be entirely within the domain of production engineering. It is mistaken however to separate the activities: innovation is most effectively achieved by teams participating together from the start embracing development, design, production and quality engineering and marketing.

The two aspects must respond and closely relate to identify a requirement or an opportunity. The UK traditionally develop a product and then engineer it; the Germans and the Japanese consider the two as one. Therefore, technologically innovation must be seen to spread throughout the whole company and not left to isolated R&D department. Marketing—product development and production engineering must be brought together at the earliest opportunity. Otherwise, products may well have been designed which the companies cannot make without heavy investment in new machines and processes.

Complete strategy involving the whole company must be set up at the earliest possible time including finance, production costings, estimates, marketing product development and product engineering.

Latterly, there is a shortage of good production engineering graduates well versed in modern technologies in the fields of automatic assembly machines, CNC equipment, robotics, CAD/CAM techniques and JIT.

Q4 *How effective are the activities of Government Departments in promoting and supporting innovation?*
A. The views we have received, suggest that in recent years, Government Departments have been very effective in this field and examples have been given to us to illustrate the point.

Provision for funding innovation has been less effective. Small companies that cannot afford internal research and development look outside for innovation and it is appropriate that they be given more favourable terms and be less handicapped by collaborative commitments. For larger companies, the emphasis on collaboration in Government schemes has merit in its own right but the basis of funding, especially, where one of the partners is a higher educational institution (HEI), as in the LINK Scheme, provides inadequate financial incentive to industry to tackle innovative work. It can rarely be claimed honestly that the proportion of funding awarded in those cases allows projects to be undertaken that would not otherwise be possible.

Q5 *What are the effects of City attitudes to investment in innovation?*
A. Generally speaking, the City does not appear to be held in high regard because the Stock Exchange is perceived as encouraging short-term investment and not supporting and encouraging innovation. The City is viewed as evaluating the company's return on capital on the one hand and criticising its unwillingness to investment in innovation on the other.

By contrast, both the German and Japanese plan for the very long-term (10 to 15 years) and are able to do so because the shareholders are providing with intimate knowledge of the reality of long-term wealth creation. Relationship between the industry banks both in Germany and Japan are very strong.

Q6 *What is the effect of the legislative and regulatory framework concerning, for example, labour costs, patent laws and tax concessions on R&D and the purchase of know-how?*
A. The effects are considered in general to be minimal in so far as innovation is concerned. Patent law is considered to be valued and provides an effective framework for protecting new design. There are no tax concessions on R&D in the UK.

Q7 *How effective are the mechanisms for technology transfer from HEIs Research Councils and the Public Laboratories to manufacturing industry?*
A. Once again, there is a difference of opinion between large and small companies on this question. For HEIs, there are large differences of opinion between expectation of academic for new work or novel work and the realities of commercialising this work by industrialists. These differences may be attributable to the very substantial costs of taking academic novelty through engineering phases to realise a marketable product. The low proportion of successful expectation of patents offered by NRDC and now DTG is consistent with this view.

For Research Councils, giving academic staff at least a share in the exploitation of the intellectual property may help by providing them with incentives to sell their novelties to the industry.

Effective technology transfer and commercial exploitation come about through active collaboration. The SERC awards for collaborative research are going in the right direction. The Teaching Company Scheme is a more firmly established scheme for promoting collaboration between academia and industry, and can provide an excellent basis for transferring innovative work from an academic source to the industrial partner.

Where innovative work undertaken in public laboratories results in a finalised product, commercial exploitation can invariably be organised by licensing arrangements with BTG. This arrangement however continues to isolate the laboratories from the exploiting companies. Product development would benefit from a more direct feedback of market information during the early development stages.

In the case of MoD laboratories, the attempts by Defence Technology Enterprises to make available to industry technology developed in those establishments, is commendable although, it is as yet too early to judge the effectiveness of this transfer operation.

Q8. *Does the UK benefit sufficiently from EEC support for innovation? How might it be improved?*

A. Study of the Official Journal suggests that there is a much greater support for high tech industry rather than heavy industry, although, what is on offer is well publicised. The onus is on individual companies to respond and the preparation and submission of applications for support are bureacratic, time consuming and many months' delay before decisions are communicated, as BEAMA is aware from first hand experience. For companies, innovation, prompt response is a vital factor.

Q9 *What are the effects of a varying relationship between companies and their suppliers?*
A. If the question is in relationship to innovation, then the majority of replies which we have received do not see the problem. However, the trend towards closer relationship between companies and their suppliers is an essential part of an innovative process. Without close involvement and detailed understanding by suppliers on a team basis, progress is slow. In this respect, reference is made to quality, price and delivery times, reliability and service.

Q10 *What factors influence decisions to invest in innovation in the UK or overseas?*
A. Innovation in manufacturing technology
Reduction in lead times and in costs.
Innovation in product development
Reduction in lead times and costs by using formal methods of designing for manufacturing and for assembly.
Reduction in cost by using novel materials. Maintaining market position. Seeking market leadership in certain areas.
Adoption of developments in systems ancillary to main products, such as control, monitoring, communications.
Generally maintaining and improving the company image in order to both influence customers' decisions and to attract good people to join.

All above are, subject to fairly stringent cost/benefit analysis. Allowance is frequently made where such factors are difficult to evaluate.

Q11 *ACOST's report Defence R&D: A National Resource.*
A. We have no experience to offer any response to this question.

I trust that the foregoing information will be of interest and assistance to your Committee in the preparation of their report.

J G GADDES
Director General
25 *April* 1990

Letter from Flexible Manufacturing Technology Ltd

Further to your letter dated 31 January 1990, please find enclosed a recent paper [not printed] I presented to the Parliamentary Group for Engineering Development. I believe this presentation brings out the following key factors:

1. The way in which the latest developments in electronics/computer hardware and software could be combined with production engineering to considerably reduce manufacturing costs.

2. The evolution of the manufacturing process from 1801 through until 1975, and how there has been a quantum leap between 1975-80, and only those countries, companies and individuals who understand this quantum leap has taken place, are able to adapt their thinking to take advantage of this. For example, most Government advisers, politicians and academics do not understand the significance of this quantum leap, and its effect upon manufacturing, and are therefore, not adapting their policies and education processes quickly enough to take advantage of this. Hence, Government Departments are not effective in promoting and supporting innovation.

3. The presentation also covers changes required in company attitudes and structures.

4. The City also does not understand the philosophy of this quantum leap and this lack of understanding leads to a lack of investment in advanced manufacturing technology by investment institutions.

I trust the presentation, and the above points, will fulfil the requirements of your letter, but should you require any further information, please do not hesitate to contact me.

M BRIGHT, OBE
Chairman
18 *February* 1990

Memorandum by the Food and Drink Federation

FDF COMMENTS

Food and drink manufacture is rapidly becoming a significant added-value, high technology industry. It is subject to increasing consumer-driven and science-driven change, and to growing international competition.

Innovation in the food industry arises broadly from several sources, including manufacturers' own product and process development requirements and new technological possibilities arising from advances in science, consumer demand, changes in agricultural production and advances in process engineering.

The Federation has had the opportunity of considering the CBI response to the enquiry and wishes to endorse its contents and add the following points of more specific interest to the food and drink industry.

SUMMARY

An adequate programme of basic underpinning research in the public sector is essential to the industry's own innovatory activities. Priorities identified in this note cover basic biological sciences (plant and animal physiology and molecular bases of quality characteristics) and human nutrition. Also vital is access to basic knowledge in the wide range of disciplines on which the food industry draws: chemistry, physics, biology, engineering, information technology, etc.

FDF is concerned at the running down of several university departments engaged in relevant research and training. There is need of an adequate supply of engineering graduates to enter the industry.

Major food companies seek for technology to transfer into innovative activity but lack of awareness is a major barrier. There are several routes, both established and *ad-hoc*, for the transfer of technology out of publicly-funded research establishments but FDF believes, in general, that the mechanisms could be greatly improved and a number of options are identified.

The Government's record in promoting and supporting innovation compares unfavourably with several of its EC counterparts. UK arrangements need to be tailored more appropriately to the real needs of the food and drink industry.

The regulatory provisions covering innovation in the food supply must be developed as appropriate to the need to give guidance to manufacturers and to ensure consumer safety without disproportionately inhibiting either technological progress or its commercial application.

Q2 *How active are UK companies in seeking out external technology, especially from overseas? How well do they adapt and apply it?*
Major food companies do seek for technology in other industries, either direct or via research relevant to those sectors in the universities, etc., which can be adapted for food production purposes. A major barrier is awareness. Most of the larger food companies operate internationally and as such have access to technologies from overseas sister companies. This is in contrast, however, to the smaller UK-only companies which tend to be far more insular and have less opportunity to explore new technologies.

Q3 *What are the respective roles played by product development and production engineering in a technological innovation?*
Continually increasing manufacturing efficiency is central to successful competition in the single market. Process, rather than production engineering is the more likely to be involved closely with technological innovation. Food process engineering differs from most other process areas in the important respects of having to handle relatively poorly defined and variable raw materials and being subject to special demands for hygiene and product safety and the frequent need to handle soft solids as well as liquid materials in both continuous and batch processes.

Process and production engineering tends to be constrained at present by the need to adapt processes and equipment from other industries to minimise the cost of engineering development. This therefore limits the construction of facilities directly tailored for food handling which results in sub-optimal efficiencies.

There is a vital and continuing need for a sufficient supply of food/chemical and other engineering graduates to enter process engineering careers, recognising the special challenges in the food and drink industry.

Some process development and process improvement activities are related to innovation but in many cases the benefits are in terms of improved efficiency, enhanced product safety and other "invisibles" which do not give rise to a change in the final product. Indeed, maintenance of a consistent product while taking advantage of technological developments is of great importance in the manufacture of major, established brands.

New product development itself derives from consumer demand for quality, variety and convenience and for foods with particular nutritional characteristics or permitting choices based upon environmental or ethical considerations.

Advancing understanding of food safety is a key influence on both product development and process engineering.

Q4 *How effective are the activities of Government departments in promoting and supporting innovation?*
Generally it is the experience of the UK food and drink industry that Government Departments by and large are not effective in promoting and supporting innovation and compare unfavourably with some of their major continental counterparts. The processing of requests for financial assistance can take too long to be commercially viable and there is an unwillingness to provide risk money to pursue promising prospects. Availability of the current LINK Programme in Food Processing Sciences is very welcome and it would appear to be one of the more successful LINK programmes. There is a need, however, to make LINK more user-friendly and to cut down the bureaucracy.

It is regrettable that the DTI Support for Innovation schemes were lost as these positively helped innovation.

The volume of administrative work involved in applying for LINK and for the various EC sources of funding is a strong dis-incentive to would-be applicants.

Q6 *What is the effect of the legislative and regulatory framework concerning, for example, labour costs, patent laws and tax concessions on R&D and the purchase of know-how?*
Food legislation in the UK is concerned with food safety and consumer information; it should not otherwise restrict consumer choice. This should be a guiding principle for future national and European legislation.

Product innovation time-scales can be very long. A new crop or wholly new ingredient takes five to fifteen years to develop to the point of marketing, much of this time being involved in safety assurance and regulatory approval.

The time taken and cost incurred in obtaining regulatory clearance for innovations can be enormous, running to years and millions of pounds. FDF recognises that the growing scope for innovation calls for an established system of control, for the guidance of manufacturers and to ensure consumer safety and thus provide the basis for consumer confidence. Novelty by itself is not, however, a cause for concern. It is those modifications which give rise to any reasonable doubts over the safety and wholesomeness of foods, or the impact of the introduction of novel raw materials upon the food chain, which should be the subject of an official assessment procedure. Because of the potentially wide range of circumstances which may have to be covered, a set of rigid procedures for novel food assessment is bound to be unsatisfactory. For this reason, FDF supports the approach taken in the draft guidelines issued by the UK Advisory Committee on Novel Foods and Processes. These set out in a logical manner the key considerations which enable a manufacturer or importer to make an initial evaluation of the safety and nutritional significance of any novelty for which they are responsible. This then leads on to selection of the appropriate scientific tests and development of as full an evaluation programme as is needed. The scheme takes account of any special considerations which might be necessary due to the use of genetically modified organisms (GMOs) at any stage in the production of the novel food or ingredient.

Since, however, the regulatory environment of the food industry must necessarily evolve to some extent with scientific knowledge, this presents the developer of a new product with uncertainties in respect of the cost and time of achieving the regulatory clearance required. As a result a large part of the protection afforded by patents, that is essential to the financial viability of many developments, can be lost. The introduction of patent term restoration for delays incurred in the regulatory process would stimulate innovation.

EC food legislation of a compositional nature can potentially restrict the scope for product and ingredient innovation. FDF has supported the Commission's mutual recognition approach to food law harmonisation which rejects development of vertical standards in favour of horizontal legislation on issues of food safety.

FDF would favour investigation of the possibility of tax concessions for research, development and innovative engineering activities. It would be necessary to produce an agreed definition of such activities to ensure that they comprised only those genuinely enabling innovation.

Q7 *How effective are the mechanisms for technology transfer from HEIs, Research Councils and public laboratories to manufacturing industry?*
The success of the industry has in no small part been due to industrial developments based on public research. Historically, the industry has carried out its own applied research and development, with little public assistance. The food industry has increased its investment in research and development faster than the average for manufacturing industry as a whole. It manages a group of research associations to take up

basic research from the public sector, to carry out collaborative applied research and to transfer technology. Many companies in addition fund research in the universities and the AFRC Institute of Food Research (IFR) and provide research training and other resources to the public sector.

The effectiveness of this applied research and development depends, *inter alia,* on a sound background of basic knowledge in the wide range of disciplines on which the food industry draws: chemistry, physics, biology, engineering, information technology, etc. FDF wishes to stress the importance to the continued success of the industry of basic research of the highest quality in these areas of science relevant to food. For example, the development of agricultural produce with enhanced consumer quality or safety or processing performance is often subject to limitations in the basic science on which it depends, particularly in the relevant biochemistry and physiology of plants and animals and the molecular bases of the quality characteristics that are sought. These areas are research sensitive and warrant stronger Government support.

Also, a concerted programme of research in the public good is needed with a much greater emphasis on providing a sound scientific basis for human nutrition. Only on such a basis can new products be designed for maximum nutritional benefit and consumers informed adequately about the nutritional significance of dietary choice, particularly given the increasing variety of available foods.

We view with some dismay the running down of, and falling morale in, several university departments engaged in research and training of potential interest to our industry.

Awareness of technology and its transfer to and from industry can, however, be improved. A number of measures are being taken by the IFR and the universities to provide mechanisms to stimulate their collaboration with industry. In our view the most effective form of transfer comes from individual public sector scientists working with their counterparts in industry and *vice versa.* We would welcome more secondments between the public sector and industrial laboratories and subject days, training courses, etc., involving both academic and industrial scientists. Individual companies have a key role to play in offering more places and promoting interchange. Individual industrial scientists could be more extensively used as advisors on the research programmes managed by MAFF and AFRC, thereby promoting awareness of opportunities for industrial application of public research.

Q8 *Does the UK benefit sufficiently from EC support for innovation? How might it be improved?*
The UK research base is gaining some involvement in shared-cost EC programmes and it is very noticeable, particularly to our colleagues in the research associations, that in some other European countries, (e.g., France, Belgium, Eire), it is the national government which supplies all or part of the balance of funds rather than the industry itself. We are told that support might also be given to companies in their efforts to apply for EC funding. This presents a situation of unfair competition within the Community and the UK Government's approach to this requires urgent review regarding the availability and sourcing of such funds.

Some members report, for example, that UK companies will seek EC funding via their interests in Eire (or in collaboration with Irish Government research establishments) due to the existence of such arrangements and of the effective availability, therefore, of one hundred per cent funding for participation in EC collaborative programmes.

Q10 *What factors influence decisions to invest in innovation in the UK or overseas?*
Since a significant proportion of the UK food industry is internationally based, ready means exist for overseas investment in innovation. This might be to the detriment of the strength of the UK industry and research effort itself, but dis-incentives to UK investment include Government attitudes to financial aspects such as the above-mentioned support of EC collaborative work, the absence of tax allowances, administrative rigmarole and a shortage of suitably trained personnel.

Letter from Sir Hugh Ford and Associates Ltd

My experience is perhaps more specialised than the Sub-committee is needing, but I will answer those questions within my competence.

1. Company attitudes

The engineers who are required to initiate and carry through innovation are *still* all too often treated as of secondary importance compared with the accountants in the financial areas of their companies. This is not only in remuneration but in fringe benefits, influence in decision-taking and promotional opportunities.

Under the attitudes of the financial houses and banks, companies all too often take their own attitudes and look upon any innovative ideas on a short-term basis, rather than a balanced assessment of the potential value of the idea on a realistic time scale.

2. There is a wide spectrum of activities from those companies who take the view "Can any good come out of Nazareth?" and go only for what has been done overseas, believing Britain has no new ideas worth exploiting, to those who are suspicious of arrangements for importing innovation.

Where I believe the main weakness lies is in seeking out good technological ideas from Universities and Research Institutes in the UK, working these up to commercial status and going out to sell them, especially abroad. It is frequently easier in my experience to sell innovation abroad than to our mature companies here: but this can only be done by collaborative ventures in which the overseas participant is contributing some of his expertise to produce a combined result in some kind of joint venture.

3. I do not believe it is possible to treat product development and production engineering as separable today. Both must be developed together.

4. Ministers' intentions are far better than their Departments to put them into action. My experience is that Departments are slow in response, superficial in their information and unhelpful in real efforts. On the other hand, our embassies abroad are now very helpful, and show real initiatives in promoting the efforts of even small companies seeking to take innovative products and processes to foreign countries.

5. City attitudes are in my experience the main stumbling block to innovation in the engineering field:
  1. They do not understand the engineering industrial and commercial requirements.
  2. They take a short-term view and penalise the project from day one.
  3. Too often, one needs to sell one's birthright even for the minimum financial backing.
  4. Even when a project is successful, they look for the first point of exit.
  5. The price for their participation is usually too high, particularly on any major innovative step.

6. No comment.

7. The mechanisms for technology transfer from Universities, Research Councils and similar establishments are probably satisfactory if really flexible approaches are made by both sides. There are ways of avoiding intellectual property rights if they are addressed from the beginning and both sides can see how to benefit from the arrangements.

8. In general, I do not know how far British companies go for EEC support. One of my own small companies has been extremely successful with Esprit (now on our third large project) and BRITE projects. In fact, this Company only survived when the City failed us by getting British, German and Danish industrial companies to support us in the EEC funding—it is easier to get than support from DTI, etc.

The requirements Boards were excellent and should never have been discarded. The results of their grants were far reaching and profitable.

9. No comment.

10. British Industry has been very tight for profits until lately and is still hesitant about taking an outward, agressive view of its ability to innovate. There is an urgent educational job to be done in many sectors. The British public is equally to blame—it often seems as though it automatically assumes a foreign product is certain to be better than a UK equivalent. We are our own worse enemy in this and it emphasises the pressing need for innovative companies to look for an international market from the beginning if it hopes to be successful with a new product.

11. No comment.

I hope these comments will be useful to the Sub-Committee.

SIR HUGH FORD
Director
19 *February* 1990

Letter from GKN plc

In reply to your letter of 7 February addressed to Mr David Lees and as indicated in my initial response of 21 February 1990, I am now able to submit a written reply to each of the points addressed by your enquiry. As I mentioned in my earlier letter, we do not envisage giving oral evidence.

Q1 *What are the effects of company attitudes and structures (including personnel policies, investment decisions)?*

Company attitudes are of paramount importance. Unless a positive commitment is made by management, innovation is unlikely to happen. A climate designed to foster innovation must be rooted in a positive cultural environment, driven by the employer. It involves the commitment of resources on an ongoing basis, in support of a long-term company strategy.

The establishment of an innovative climate goes hand-in-hand with other elements of corporate culture, such as a commitment to quality and to providing the best possible product or service to the customer. The companies that succeed will be those that strive for competitive advantage by seeking to achieve excellence in all their spheres of activity. Innovation as defined in this inquiry, as opposed to technology for its own sake, is a key element in this.

The narrow technology based definition of innovation sometimes leads to an incorrect perception, that innovation is poorly rewarded financially. In a competitive market, financial success should be a reflection of competitive advantage, and innovation in the wider sense has a key role to play in bringing this about.

GKN's principle areas of businesses activity centre around the supply of automotive components and industrial services to various sectors of industry. It aims to fulfil these particular roles better than its competitors, that is to say, in a way that more fully meets the requirements of its customers. Its quest for excellence is subject to the particular business environment in which it operates, and to the needs and requirements of its customers. The key areas of advantage are those of process technology, quality and reliability. Therefore, although GKN is not generally at the forefront of new product development, it is actively innovative in pursuit of the aims and objectives of it's businesses.

A factor influencing corporate attitudes and structures in the UK is that there tends to be a more restrictive functional specialisation amongst employees than elsewhere in the European Community, and attempts to increase the level of diversity within the less senior career structures are not always well received. This can be a negative feature, which may be mitigated by the adoption of positive policies designed to encourage more flexible approaches. Within a multinational group structure, the problem is generally less acute, and non-existent at more senior levels of management, where a more generalised management competence and diversity of experience, together with an international outlook are essential prerequisites.

It is also the case that in the UK, engineering and science backgrounds are less common among senior management. This is not necessarily an obstacle to innovation, although in practice it sometimes is. Innovation, as defined by the Sub-Committee, goes beyond technical issues, and suggests a concept of "pervasive innovation" which is equally applicable to such diverse functions as finance, sales, marketing and personnel. Therefore, whilst a background in science or engineering may be regarded as a positive factor, since it nurtures a logical and consistent approach to the application of new knowledge or techniques, an innovative company culture is rather more important in realising the economic benefits that they offer. An example of this type of approach is that of Total Quality Management (TQM). Quality is essentially an engineering concept but, as those companies that have made the commitment to TQM have shown, it is equally applicable to all aspects of corporate activity.

Until recently, personnel policies have tended to favour a hierarchical form of career development which is not necessarily conducive to the commercial exploitation of significant new knowledge and techniques. This approach is gradually being superceded by a less structured view of career development, better able to reconcile personal career goals with the most commercially sensible application of key skills. An example of this approach would be where those involved with critical projects are encouraged to oversee their development throughout the various functional stages, from the initial research and development through manufacturing and into the marketing environment. A significant element in the success of Japanese companies in the field of product development is the use of product development teams, combining expertise in the various development functions, to oversee a project through to implementation.

The influence of large companies or groups on technology transfer and innovation is often underrated. Large firms can in practice be as fast and light on their feet as smaller enterprises, and have the considerable advantage of greater resources. Large corporations are able to take a long-term approach to research and development and therefore to sustain substantial long-term R&D costs in relation to turnover; they are well placed to train and develop staff expertise, thereby creating a fund of knowledge and experience, for the benefit of industry as a whole—this is of particular importance to UK industry, a principal weakness of which is the lack of an adequately trained and experienced workforce; they have diversified portfolios of businesses which enable them to cross-subsidise research and development between different businesses; they are active in technologically intensive areas of business, and are able to bridge the gap between basic, strategic and applied R&D. In the UK, there are some 20 large corporations which can reasonably be regarded in this light, of which GKN is one. These companies contribute to the direct and indirect diffusion of new information, partly through other, often smaller businesses which adopt innovations made possible by them. In this way, the social benefit of innovation is considerably greater than the narrow financial return to the developer. Unfortunately, the UK has relatively few such companies, compared to the other major industrialised countries.

Technology transfer is a key factor in innovation. Unfortunately, many companies still suffer from the "not invented here" syndrome. Again, the company culture will tend to determine whether this is a major obstacle or whether, in line with the objectives of top management promulgated throughout an organisation, it can be supplanted by a desire for "implemented here".

Q2 *How active are UK companies in seeking out external technology, especially from overseas? How well do they adapt and apply it?*

Traditionally, UK companies have not had a good record on seeking outside technology. This attitude has its origins in the UK's early industrialisation and near monopoly of key export markets, which allowed commercial success to flow from indigenous technology. Language is also an important factor. The use of English and the globalisation of markets and industries have enabled countries such as Germany, Japan and France to exploit UK source material, whilst UK companies remain at a disadvantage in terms of accessing foreign language material.

In addition to its UK research and development facilities, GKN has for some time had product development facilities both in the USA and Germany, and a technology intelligence office in Japan. It has recently broken new ground in the UK, on a small scale, with "Project Extra", which seeks to provide inventors with an avenue for the joint development of inventions and for their commercial exploitation: it remains to be seen whether this experimental project proves to be economically viable. Although the product range in GKN Automotive is relatively narrow and both GKN Defence and GKN Sankey tend to make to design, with any requisite R&D being undertaken on behalf of and within the guidelines laid down by the customer, we always seek to be innovative in the ways in which we meet our customer's requirements and in how we adapt and apply the new knowledge or techniques gained. Innovation in the wider inter-corporate and geographical, as well as the functional sense is an integral part of the GKN Group culture.

One positive development which is worth noting is the increased aggressiveness of the academic sector in seeking partnership with industry for innovation. This is a relatively new phenomenon, which shows considerable promise and could provide British industry with a competitive advantage, both within the European Community and internationally.

A basic difficulty facing UK industry, although it is less inhibiting than previously, is that of restrictive working practices. Where these remain, they make the application of new technologies difficult, irrespective of whether they are sourced internally or externally, including overseas.

Q3 *What are the respective roles played by product development and production engineering in technological innovation?*

In order to consider the respective roles played by product development and production engineering, it is necessary to examine how and why technological innovation takes place. This may be due to:

- Market or demand "pull", where there is an evident consumer need or requirement.
- (Funded) research and development identifying new processes or applications, which give rise to new marketing opportunities.

The product and the process together make up technological innovation, but they are perceived rather differently. New product technology, comprising a combination of design, material and marketing innovation, tends to be regarded as attractive, both in terms of job satisfaction and career development. It attracts the best people. Process technology, including production engineering, is often seen as more basic and less attractive. As a result, implementation is often relatively badly done in the UK. Although this perception started to change slowly in the late 1980s, there remains a problem of how to make production and process engineering more attractive.

An important consideration is that of career prospects. For the sake of comparison, in Germany it is relatively more common for production engineers to reach the top echelons of management than in the UK. It is therefore seen as offering more in terms of career development, than in the UK.

Q4 *How effective are the activities of Government departments in promoting and supporting innovation?*

Government departments promote a number of initiatives, such as LINK and SMART, together with major European Community programmes such as BRITE/EURAM and EUREKA. On all of these, the DTI has adopted a commendably high profile. However, UK participation tends to be patchy. This is due to a degree of confusion amongst industrialists about the differences between the various schemes and their appropriateness to any given set of circumstances. Many would benefit from more guidance.

There is also the considerable cost of submitting competitive proposals, with the proportion of successful bids under some of the European Community schemes being unacceptably low. In addition, there is the difficulty of competitive interest, which tends to inhibit participation in collaborative activities. GKN has for some time pursued a policy of active involvement and is for example, currently participating in a number of BRITE projects.

Q5 *What are the effects of City attitudes to investment and innovation?*

City attitudes are generally related to the overall success of a company in achieving its objectives, which is reflected in the financial and other indicators that analysts take into consideration.

Innovation needs to be seen in this context. Business must live with the environment within which it operates, and achieve success through good management, which includes ensuring not only that the corporate culture is innovative, but also that the innovation that is undertaken is carefully targetted towards the requirements of the business concerned, the needs of the consumers of its products and the interests of its shareholders. It must be a vehicle through which higher earnings may be achieved. Although certain types of basic R&D in new technologies incur above-the-line charges with no short-term returns, these activities rarely represent a significant proportion of earnings, and are unlikely to be a perceived negatively, as long as the business has a good track record. In the experience of GKN, City attitudes have not had a negative influence on innovation in any of the Group's areas of activity.

There is a difference in attitude to innovation between the UK and such countries as Germany and Japan, where investment and innovation do tend to be more targetted. Japanese companies are good at identifying high growth potential product markets, and following through with innovation on a consistent basis. However, this is a question of management practices, rather than of the attitude of the markets. Similar considerations apply to the issue of the vulnerability of UK companies to hostile takeover. Companies with high R&D costs, but no obvious commercial strengths present opportunities for short-term gains, since profitability can be boosted by simply removing R&D and related costs from the financial picture. The danger of a potential loss to the UK's technical capability is in practice relatively small, since a low market valuation is often an indication of bad management with little prospect of earnings growth through real innovation.

Q6 *What is the effect of the legislative and regulatory framework concerning for example, labour costs, patent laws and tax concessions on R&D and the purchase of know-how?*
The legislative and regulatory framework represents a complex structure, the effects of which are difficult either to determine or to quantify. This is not, however, to underestimate their impact. One of the most tangible aspects is that of the difficulties that differences between national frameworks create in cross-border transactions involving innovation, particularly in terms of intellectual property rights. Differences in tax treatment result in different degrees of incentivisation. Although R&D expenditure is allowable against tax in the UK, this precludes capitalisation. Certain countries such as Australia, subsidise R&D by providing tax allowances in excess of 100 per cent. In Japan, a more selective approach is adopted, with MITI very much in the business of picking winners. In Germany, the rights of the employee/inventor are more fully protected. Changes to the UK approach in this direction might well encourage more useful employee involvement.

Q7 *How effective are the mechanisms for technology transfer from higher educational institutions, research councils and public laboratories to manufacturing industry?*
Within the academic environment, the pressures are in favour of publishing to the world at large. This enhances the reputation of the academic involved as well as that of his institution, and thereby adds to the marketability of both.

However, it does not encourage the transfer of technology to manufacturing industry. Recently, the SERC has begun to place more emphasis on direct UK company participation in funded research, but so far this represents only a small change in emphasis. A further difficulty, particularly with research institutes, is that they require too large a payment too soon in the process of technology transfer, i.e., before commercial viability is proven.

Technology transfer is essentially a person centred activity. In the UK, with exceptions, there is no tradition of career progression from higher educational institutions, research institutes and public laboratories to manufacturing industry. The recent trends, of closer collaboration between manufacturing industry and academic institutions which are aggressively seeking commercial project participation, may point towards an increase in cross-fertilisation in the future.

Q8 *Does the UK benefit sufficiently from EC Support for innovation? How might it be improved?*
GKN has actively participated in BRITE/EURAM projects which derive from Anglo-French initiatives. There is a feeling in industry that more should be done to garner a greater proportion of EC research funding for British companies. Against this, the cost of bidding for having a project accepted under EC support schemes, together with the current level of over-subscription, tend to be major disincentives.

The very considerable costs involved relate both to the financial costs of preparing a case and to the administrative delays and uncertainty which tend to be particularly damaging to innovative processes. There is also an element of dirigisme involved, which many regard as an unnecessarily regulatory and bureaucratic approach on the part of the European Community.

Q9 *What are the effects of the varying relationships between companies and their suppliers?*
The trend in industry has been for the relationship between companies and their suppliers to become deeper. This new environment, exemplified by the Ford Q1 awards scheme and the "supplier audit" which it entails, has resulted in an improved exchange of information and a collaborative approach to meeting the challenge of cost pressures. This has created an environment which is particularly conducive to innovation. Investment in innovation must involve the customer, as both supplier and customer depend in the final analysis on the commercial success of the final product. GKN itself is seeking closer relationships with its suppliers of such products as resins, metal powders, components and sub-assemblies.

The enhanced relationship between companies and their suppliers is a key element which is affecting the evolution of corporate cultures. Whilst a company cannot, in effect, "invest" in innovation in the absence of the right environment, the collaborative approach which is becoming the norm, and involves considerable investment of capital and manpower is important in fostering an innovative climate.

Q10 *What factors influence decisions to invest in innovation in the UK or overseas?*
Since the decision to invest in innovation needs to be made within the context, and against the background of the aims and objectives of the business, and the corporate culture that they engender, the decision whether to invest in the UK or overseas should be determined by the extent to which innovation in the UK is

consistent with these strategic considerations. This, in turn, will be influenced by the prevailing business environment, including such factors as skills availability, factor costs and availability, trends in the relevant markets and trade-offs in relation to a variety of legal, fiscal and cultural factors. A key consideration will invariably be the availability of the right people, in which education and training are fundamental considerations.

Each investment decision, whether or not it involves innovation, and wherever located, should be analysed and assessed as to its commercial viability, against a range of appropriate performance indicators set on the basis of the essential strategies of the business.

Q11 *In the light of ACOST's report—"Defence R&D, a National Resource" and the Government's response, is there a satisfactory relationship between the defence and civil sectors?*

The defence sector accounts for a quarter of the UK national R&D budget, and it is therefore important that this should make a positive contribution to innovation in industry as a whole. The ACOST report has shown that, in practice, this is often not the case. Therefore, although the Government is right to contend that a proportion of defence R&D has limited or no civil relevance, and that some types of research will not be appropriate to the involvement of the civil sector, it seems that there is considerable scope for greater interaction between the civil and military sectors.

There are a number of approaches which would assist in furthering this objective:

- R&D projects could be so specified as to encourage less specific research which could have relevance to more than one defence project and greater application to the civil sector. This would require the involvement of industry at an earlier stage in project specification.
- The private sector is better able to manage and control risk, and could be encouraged to put forward proposals involving new developments in knowledge and technology to the MoD on a competitive basis for Defence Budget funding. This would help to encourage pre-competitive R&D in industry and enhance industry's defence related research capability. It would also reinforce the Government's objective of carrying out an increasing proportion of research on an extramural basis, and would relieve the MoD of much of the technological and financial risk assessment.
- The Government could be encouraged to foster the "spinning in" of new knowledge or techniques developed by industry, thereby using its funding capabilities, not to sponsor research on a generalised basis, but to introduce a commercial incentive for companies in related fields of activity.
- A key element in developing a satisfactory relationship between the defence and civil sectors is the adaptation and commercial exploitation of the knowledge or techniques gained.

  The French policy of employing the advancement of defence technology as a locomotive for general technological progress, deliberately placing R&D work with enterprises which can be expected to apply what they learn in their military activity to good commercial advantage, is relevant in this context. The awarding of contracts to those organisations with proven technology transfer mechanisms is not an approach which has been advanced in the UK, where received wisdom has suggested that small- or medium-sized enterprises may be best placed to exploit new technologies. In fact, it is the larger organisations with a long-term approach to product and process development that are best placed to act as a conduit for the direct and indirect diffusion of innovation. Therefore, the MoD practice of placing work with large and well established contractors is unlikely in itself to be an obstacle to innovation. Whilst it may be true that some large companies, as suggested by the ACOST report, do not in practice possess the corporate culture or incentives necessary for diffusing and exploiting such technologies, this is not a function of size but of the effectiveness of management.
- The European Commission is following an approach designed to broaden collaborative EC R&D programmes in future to include both civil and military interests. This should provide a framework of cross-fertilisation which should further aid the development of a new relationship between the UK national defence and civil sectors, to the benefit of innovation.

If you require any further information, please do not hesitate to contact me.

LESLIE GUNDE
Head of Business Information
4 *April* 1990

Memorandum by Glaxo

Glaxo is an integrated research based group of companies whose corporate purpose is the discovery, development, manufacture and marketing of safe, effective medicines of the highest quality.

UK-owned, Glaxo is one of the world's largest and fastest growing pharmaceutical companies. Sales totalled £2,570 million in the financial year to 30 June 1989. Nearly 38,000 people are employed by Glaxo in 70 operating countries and Glaxo medicines are sold in about 150 countries.

Ethical pharmaceuticals are the products of an innovative, science based industry. The Industry's success depends on research and development which is very expensive. Glaxo expenditure on R&D in 1988/89 was £323 million and is estimated to rise to over £400 million in 1990.

The following is a summary of Glaxo's response to the questions raised by the committee:

Q1 Glaxo's overall company philosophy and personnel policy are set out emphasising the importance of the correct balance between a clear central purpose and local autonomy and responsibility.

Q2 Glaxo's imports of technology are generally limited to the purchase of specialist capital equipment not available in the UK.

Q3 Product development in the research based ethical pharmaceutical industry plays a far more important role than production engineering, which is mainly limited to the development of new forms of packing or delivery for medicines.

Q4 We have commented separately on our relationship with the two Government departments with which we have most contact—the Department of Trade and Industry and the Department of Health.

Q5 Glaxo's past record of success means that the City is usually willing to support our continued high levels of investment in innovation. We also benefit from generating enough cash availability to obviate the need for constant city support.

Q6 The importance of strong and equitable patent laws is explained, difficulties with local tax inspectors are raised and the strengths and future of the Pharmaceutical Price Regulation Scheme (PPRS) are discussed.

Q7 Technology transfer is not generally an expectation from the types of collaboration into which we usually enter. The types of project with which we are involved are set out, the benefits to Glaxo are explained and some problems are aired.

Q10 The factors influencing investment decisions are set out and the reasons for the expansion of our overseas R&D operation are explained.

Q11 *What are the effects of company attitudes and structures (including personnel policies) on investment decisions?*

1.1 Glaxo runs its affairs as an integrated business where geographically dispersed activities are unified by a common strategy and are brought together to work to common policies by a clear system of central co-ordination. A particular kind of management and organisation philosophy underlies this approach. It tries to combine strong central leadership with the delegation of full operating responsibility to subsidiary and associated companies spread across the world. The greatest importance is attached to our system of delegation, since it is this which provides the mainspring for growth by creating the conditions which enable and require the General Managers of our operating companies to act as entrepreneurs. Thus we both encourage and expect them to act with dynamism, competence and imagination on the basis of deep knowledge and sensitivity to the market and its potential for growth; and to conduct the businesses not only with commercial success, but also as a good citizen of the country in which they operate.

1.2 Because we place emphasis on delegation, it is essential to have a strong and refined process of central direction, so that the freedom on which delegation thrives is properly exercised. There are three elements to this process in the Group. The first, and the driving force of the whole exercise, is summed up as leadership and command. It is the responsibility of the Glaxo Holdings Board to lay down, and constantly revise, a framework of policies to see that our corporate purpose is realised and that all our functions and activities, with their different time frames and complex interaction, are properly directed towards it. The second element is a central co-ordinating role, which involves the actual day to-day, world wide co-ordination of the functions, operation and activities of an integrated business to make sure that the Group's compounds are efficiently developed from discovery to marketing. And the third, and exceedingly important element of the process which permeates the first two, is to set the proper standards of quality in all we do, from research and development through production to marketing.

1.3 The practical effects of Glaxo's central philosophy manifest themselves at every level of our operations. For instance, each of our worldwide trading company managers can be confident that any sound business proposal which is consistent with Glaxo's corporate policy will be supported by the board and receive adequate funding.

1.4 This philosophy permeates throughout the company at all levels. For example, Glaxo operates an increasing number of Quality Circles at its UK sites where small groups of staff volunteer to meet for problem spotting and solving sessions as a way of helping to improve further the quality of our products. Benefits are also evident beyond the value of the ideas developed, in terms of staff commitment and involvement.

1.5 In addition, Glaxo operates a staff suggestion scheme which encourages and rewards innovative ideas from individual staff. For example, a bonus of £13,000 was recently awarded to one of our production line workers who devised a mechanism to prevent bottles falling over during filling at our plant in Durham. Production staff at Ware have recently received awards for an idea which will save the company £60,000 per annum.

1.6 It is the correct combination of clear central purpose together with maximum local autonomy and individual responsibility, which we believe form the optimum basis for targeting and exploiting investment and encouraging innovative thinking from every employee.

Q2 *How active are UK companies in seeking out external technology especially from overseas? How well do they adapt and apply it?*

2.1 Glaxo is an international group of companies which operates in some 70 countries world wide. We carry out primary research in Europe, North America, India, Japan and Singapore and have manufacturing plants in 29 countries across the world. As a major multi-national we are well placed to keep abreast of all available opportunities. In practice Glaxo imports technology in three broad areas, R&D, people and equipment.

Research and Development

2.2 The benefit to Glaxo of research on an international scale is derived in great measure from the different academic backgrounds, cultural traditions and medical approaches in each country in which we operate. It is also the case that medicines may affect people of different races in different ways and that different diseases occur in different parts of the world. The broad international spread of our R&D is therefore necessary to ensure the maximum safety, efficacy and contribution of our products.

People

2.3 No matter how good a company's organisation, its successful operation depends on people. Glaxo now has a management team which is international in composition. Executive directors are currently drawn from Italy, Switzerland, Japan and the United States as well as from the UK. It is interesting to note that four years ago the entire Glaxo board was British. Today, only three executive directors originate from this country. This is a reflection both of the group's worldwide interests and its determination to employ the best talent available in the world.

Equipment

2.4 Glaxo buys very little home produced high technology equipment because it is simply not available. What British equipment we do buy tends to be general laboratory items such as waterbaths and flow cabinets. When furnishing our research facilities or updating our production lines, we buy the best equipment available regardless of its country of origin. We would gladly buy British but reliability, service and cost would need to be competitive with the best US, German and Japanese companies.

Q3 *What are the respective roles played by product development and production engineering in technological innovation?*

3.1 Product development and production engineering play roles of varying importance in technological innovation in different industrial sectors. In the research-based ethical pharmaceuticals industry, product development plays a crucial role in the progress of the industry, whereas that of production engineering is relatively less prominent. (The relationship may be different in the generic sector of the pharmaceutical industry, where off-patent medicines discovered and developed by others are manufactured and where cost effective production technology is relatively more important).

3.2 Product development in the pharmaceutical industry is very different to that in other industries. The entire process of researching and developing a new drug is a prerequisite to marketing. In our industry market evaluation has little place in R&D, following the assessment that a particular field of research has the potential to make a significant contribution to healthcare.

3.3 For the research-based pharmaceutical industry the process of turning a promising, newly discovered molecule into a safe and effective medicine takes a number of years (10-12 years is quite typical for the industry as a whole), and costs a great deal of money. Recent figures show the average research and development cost per new medicine launched to be around £100 million.

3.4 The great majority of today's new medicines have been born through systematic scientific investigation, based on an understanding of:

- The mechanisms of disease (pathology).
- How it can respond to new treatments.

This basic knowledge mainly results from fundamental research carried out in universities and hospitals (some of it funded by the pharmaceutical industry). The industry itself—with 17,000 people employed directly in research in the UK—then applies that knowledge to the discovery and development of new medicines.

3.5 During early research, thousands of compounds may be synthesised and screened. It may take many years to isolate genuinely useful ones that could help treat disease in man. Chance discoveries are rare and they, too, demand confirmation and extensive development.

Preclinical Development

3.6 Once a new compound has been identified or designed—increasingly, using techniques such as computer modelling—a whole series of tests and trials needs to be carried out to measure its potential efficacy to treat a particular disease and, if active, its safety profile (including unacceptable side effects). The effect of a new compound can be measured initially on isolated cells or tissues ("in vitro" tests). Such tests quickly identify potentially useful agents and eliminate inactive or toxic compounds. Further "in vitro" tests leading when appropriate to animal studies ("in vivo" tests) are then carried out with compounds that have a real potential of leading to a new and improved medicine. These studies are necessary before a new medicine can be given a product licence and are strictly controlled by law.

Clinical Trials

3.7 Clinical trials—which must first be authorised by the Department of Health—provide confirmation of the safety and efficacy of a medicine on the human body. Initial studies are conducted on healthy volunteers (often pharmaceutical company researches) and only then on patients who have the condition which the medicine has been developed to treat.

3.8 Research and development, taken together, commonly accounts for around 13 per cent of a company's turnover. Glaxo would estimate that about 70 per cent of R&D expenditure is devoted to development. This makes pharmaceuticals one of the most research and development intensive industries in Europe. Competition in this industry is a function of the quality efficiency of this product research and development process.

3.9 Product development and production engineering combine when it comes to developing new production techniques and delivery mechanisms for medicines. Glaxo recently purchased laser drilling technology in order to develop a new mechanism for the controlled release of medicine in the body and we have developed a number of innovative inhaler devices for the delivery of anti-asthmatic medicines.

3.10 As a generalisation, however, production engineering is not of the same order of importance as product development to the economic success of the industry or to the effectiveness with which it meets its social goals of the development and marketing of new and better medicines to treat human disease.

Q4 *How effective are the activities of Government Departments in promoting and supporting innovation?*

The Department of Health (DoH)

4.1 Our relationship with the DoH is based upon the dichotomy of the Department fulfilling the dual role of both our regulator and sponsor. Through the Pharmaceutical Price Regulation Scheme (PPRS), the department seeks to obtain medicines of the NHS at a reasonable price and ultimately controls our profits. As our sponsor department the DoH is also responsible for encouraging a prosperous and thriving pharmaceutical industry. It is a delicate balancing act for the DoH to perform but, on the whole, we have a good relationship with the Department.

4.2 Our relationship is, however, undergoing some change as a result of the implementation of some of the measures in the National Health Service and Community Care Bill which are designed to put downward pressure on the medicines bill. Whilst we are generally supportive of the intentions of the Bill to strengthen management practices in the NHS, the introduction of demand side controls on medicines expenditure is a cause for concern. The PPRS already provides a supply side mechanism for controlling the medicines bill and introducing demand side controls such as the indicative prescribing scheme may lead to confusion. We are reassured by the Government's latest statements on the continuing availability of funds for all necessary medicines, but we are concerned that some NHS managers appear to consider cost cutting as their first priority. We are also concerned that some GPs do not fully understand the true position and doubt their freedom to continue prescribing in the best interests of their patients.

4.3 In addition to its profit regulation and sponsorship responsibilites the DoH also has a functional role as far as our industry is concerned. The DoH is responsible for issuing clinical trial certificates, manufacturers' licenses and product licenses under the Medicines Act 1968.

The Department of Trade and Industry (DTI)

4.4 We have traditionally had a very good relationship with the DTI which, through the BOTB, has provided valuable support for our overseas trade. The pharmaceutical industry is the second largest positive contributor to the UK's balance of trade. Last year the industry as a whole contributed £955 million. Glaxo's exports were £618 million in the year to June 1989.

4.5 The DTI has also consistently supported our efforts to obtain adequate patent protection for our medicines throughout the world through GATT and TRIP (Trade Related Intellectual Property). We would now urge them to continue those efforts by supporting the European Commission's proposal for the creation of a supplementary protection certificate for medicinal products. (See our response to Q6).

4.6 Our relationship with the DTI is particularly important because it takes the lead in Whitehall on single market issues. Approximately 10 per cent of the Commission's original single market proposals are in the area of health care. It is no exaggeration to say that the pharmaceutical industry is being restructured by the EC, but there is an unfortunate perception within the industry that our interests are not being adequately represented because of the wider interests of the Government. By this, we mean that the Government's perceived attitude towards the EEC leads to reduced participation in developing detailed proposals in some areas. There are many areas where Glaxo does not consider EEC regulation to be necessary or appropriate. Nonetheless it is essential to participate fully once it becomes clear that regulation is inevitable.

4.7 The DTI is also responsible for the operation of the LINK programme which is designed to encourage academic and scientific collaboration in R&D. Glaxo was involved in the very first LINK project announced in October 1988 to research the use of enzymes in industrial chemistry and has since participated in a number of further projects.

4.8 Glaxo does not require substantial financial assistance from the Government. All that we ask is that obstacles are not placed in our way and that we can compete on a level playing field with our international competitors from Japan and the USA.

Q5 *What are the effects of city attitudes to investment and innovation?*

5.1 Historically, Glaxo has not needed to approach the City to obtain funds for R&D projects since we are in the fortunate position of generating cash revenue from sales to obviate the need for external assistance.

5.2 Despite the self-sustaining nature of our R&D activities we have still experienced, in a small way, the results of the short-term view of the City. The pharmaceutical industry has much longer horizons than most others and it spends enormous amounts on long-term R&D. At Glaxo we are sometimes under pressure from the City to reveal our R&D activities earlier than we might otherwise have wished. The problem with early disclosure of this sort of information is that it may be open to misinterpretation by City analysts who may react unfavourably to learning that one or two compounds have been dropped from our research portfolio even though this is perfectly normal practice.

5.3 Glaxo will, however, continue with our R&D presentations to the City because we believe that they aid and assist open and constructive relations which will hopefully lead to a greater understanding of the particular needs of our industry.

Q6 *What is the effect of the legislative and regulatory framework?*

6.1 The pharmaceutical industry is quite properly the most regulated industry in the British economy. Every aspect of the industry from R&D to marketing is subject to regulation, and the Government even controls our profits through the Pharmaceutical Price Regulation Scheme (PPRS). Within this tightly controlled regulatory environment there are a number of issues which currently concern us.

Patents

6.2 The UK's pharmaceutical industry is one of the country's most successful industries. Not only does it provide an increasing range of medicines for NHS patients, but it also contributes handsomely to the country's balance of payments. The industry earned more than £2 billion in exports last year, and its industrial sector is the second largest net contributor to the balance of trade.

6.3 The future success of the industry is reliant upon continuing research and development into new medicines which is both expensive and time consuming. Last year Glaxo invested £323 million in research and development which represented 13 per cent of our turnover and this expenditure is likely to rise as we increase our efforts to discover important new medicines. However, we are only able to maintain our increased investment in R&D if we have adequate opportunity to generate sufficient income through sales of patented products. The pharmaceutical industry is almost uniquely dependent on patent protection by the nature of its products which are easy to copy once produced but enormously expensive to discover and develop in the first place. The protection of intellectual property is the most basic of the industry's needs and innovation does not flourish where adequate protection is not afforded.

6.4 Under current patent law new compounds are, in theory, afforded 20 years of protection. But the clock starts from the date of filing the application, and with a development time of 10-12 years needed to bring a new product to the market, this leaves an effective period of protection of only eight years. The European Commission has recently produced proposals for the creation of a supplementary protection certificate for medicinal products which would extend the protection of a pharmaceutical product by up to 10 years (subject to a 16-year maximum). It is important for the future well-being of R&D in the pharmaceutical industry that the government supports the EC proposals.

6.5 The most important reason for restoring to pharmaceutical companies an acceptable period of on-the-market protection is simply one of equity. Patent term for signatories to the European Patent Convention is intended to be 20 years. Even allowing a maximum of four years for tooling up, other industries benefit from at least 16 years effective patent life. The pharmaceutical companies take higher than average risks, invest above average proportion of turnover in R&D and properly fulfil the highest regulatory demands of any industry. The industry is not seeking special favours, it is merely seeking parity.

6.6 Recouping investment is neither the primary purpose of patents nor immediately relevant to current research in the pharmaceutical industry. Research is funded from current revenue, and current revenue derives from compounds researched a decade or more previously. Moreover, the industry must "recoup" not only the costs of one successful product, but also the costs of the 9,999 compounds which fail to reach the market. In fact, pharmaceutical companies are not motivated to "get back" monies invested ten years previously, they are motivated to gain sufficient revenue from current sales to fund the research—both successes and failures—of the next 10 years.

6.7 Currently the Government, as evidenced by Lord Ullswater's speech to the House of Lords in the debate on patent protection in the EC (25 April 1990), appears to consider the intellectual property question of patent restoration side by side with ways of controlling health spending. In our view this is wholly inappropriate. Patent rights should not be used as an artificial and additional means of cost control.

Tax concessions on R&D

6.8 Current tax rules allow the whole of our capital expenditure on R&D to be written off in the year in which it occurs. Naturally, this is a considerable incentive to invest in R&D and we would not want the arrangement to be changed. However, local tax inspectors are seeking to re-define R&D, without any apparent instruction from government, by splitting research from development, effectively removing tax relief from capital spent on development. The local inspectors' position is based on the premise that research is complete once a medically active compound has been produced, but this makes no allowance for the further work which is needed to ensure that the new compound is safe and effective.

6.9 Like the rest of the pharmaceutical industry we believe that Parliament alone should be responsible for defining these crucial issues.

Attitudes to pricing

6.10 Pharmaceutical profit levels in the UK are tightly controlled by the Government through the Pharmaceutical Price Regulation Scheme (PPRS). The scheme lays down the maximum return on capital that is permissible for a pharmaceutical company to make on its UK sales. The PPRS has been in operation since 1957 and is monitored by the Public Accounts Committee. It is a unique system. No other private company or sector in the UK is subject to this degree of Government financial control.

6.11 The Government, as the PPRS states, has to strike a balance between its responsibility for public expenditure on medicines and the need to encourage the research-based industry in this country. In 1986 the Public Accounts Committee recommended that the balance was wrong and had been tipped against the legitimate needs of industry.

6.12 The current PPRS which came into force in October 1986 for six years, reversed part of the reduction in allowable profits and intended to introduce a more objective method of assessing return on capital employed (the key indicator), to be used from 1988-89. This has not yet been achieved, but if introduced it would keep the allowable rates of return on capital in line with changes in the average profitability of UK industry generally.

6.13 The strengths of the PPRS are that it is a flexible, voluntary, negotiated working arrangement between two parties—the Department of Health and the industry as represented by Association of the British Pharmaceutical Industry. No other European Community country operates a scheme like the PPRS for regulating pharmaceutical company profits and the most common system in these countries is for each medicine to be given its own individual price, which is an extremely complicated and time-consuming process.

6.14 One of the benefits of the flexibility of the PPRS is that it allows pharmaceutical companies freedom to fix the price of a product on launch. This is an important benefit since it gives the industry the opportunity to generate sufficient income to fund the substantial investment necessary for future R&D projects.

Q7 *How effective are the mechanisms for technology transfer from HEIs, Research Councils and public laboratories to manufacturing industry?*

7.1 As a major international business, engaged in the discovery, development, manufacture and marketing of safe, effective medicines of the highest quality, Glaxo looks to higher education to provide it with well-educated, skilled and adaptable staff, to encourage the study of scientific and technological subjects and to carry out basic scientific research. Glaxo companies therefore have a vital interest in the educational system and attach importance to the development of a variety of links with education. The degree and nature of these left to the management of the individual companies.

7.2 Technology transfer within the pharmaceutical industry tends to be rather haphazard and is not generally an expectation from the types of collaboration into which we usually enter. The value we get from our collaborations comes from the exchange of ideas that occur during the course of a collaboration if it is properly established and run. This can result in a two-way transfer of information and may also have the effect of directing minds of academic collaborators to the needs and philosophies of industrial research. This can have two effects. The first is the orientation of academic research towards problems of more practical importance to the discovery and use of new medicines. Secondly, it is hoped that it may have an impact on undergraduate training and the design of courses more suited to the needs of Industry.

7.3 In addition to collaborative projects Glaxo also enters into arrangements with HEIs for the provision of services or the performance of short investigations in areas in which they have expertise. Most usually these are carried out under contracts which are very specific and they are usually in areas where we feel it inappropriate for us to develop the test system or whatever in house.

7.4 There has been a noticeable change in the attitudes of the universities in particular towards industrial collaborations. Some of these have been less than helpful in the context of the pharmaceutical research field. A recent development has been the introduction of Industrial Liaison Units in many universities whose aim is clearly, and rightly, to exploit the expertise and services that a particular university has to offer industry. Unfortunately, in our context, they are often counter-productive and erect barriers between industrial scientists and their academic colleagues.

7.5 Problems often arise because of a lack of understanding on the part of the Industrial Liaison personnel of the very different nature of the pharmaceutical industry in comparison with other industries, such as those in the engineering sector, for example. They have little or no appreciation of the processes underlying the discovery of new medicines and the need for the basic biological and chemical research we employ. They also have little appreciation of our own very significant resources, both in terms of scientific manpower and facilities, that we need to maintain in-house. There is also a tendency for educational establishments to get out of proportion their contribution to our research programmes. The value of work carried out on our behalf in HEIs is insignificant when compared to our own long-term, in-house research and this failure to see the contribution of HEIs to the discovery research process needed for a new medicine in the correct perspective often gives rise to unproductive arguments over royalties.

7.6 A further problem that is becoming increasingly visible is the failure of the infrastructure within university departments to support modern biological and chemical research. Increasingly the industry is being asked to supply major and essential pieces of equipment for a project; we are being asked to refurbish laboratories and to support new building programmes. The infrastructure is fundamental to quality science in UK HEIs and we cannot see this as being the responsibility of industry. In the course of the year ending 30 June 1989 the financial value of the contribution made to higher education in the UK by Glaxo was £5.2 million which supported students and/or projects in 59 HEIs. Whilst we are prepared to continue a mutually beneficial partnership programme with HEIs, we are not prepared to fund basic infrastructure needs. If the infrastructure falls below a certain level then collaborations with academic groups are going to become a less positive proposition for us.

Q10 *What factors influence decisions to invest in innovation in the UK or overseas?*

10.1 Decisions to invest in innovation, in the UK or overseas, will only be made if there is a reasonable prospect of obtaining an adequate return on that investment. Provided that prospect exists, a prime requirement in determining the location of investment by a company such as Glaxo, which operates worldwide, is the availability of suitable skilled and creative manpower. In that regard, the UK has much to offer; moreover the cost of employing highly qualified manpower in the UK is, in international terms, relatively low. There is also a well-established scientific culture in the UK, with a traditionally strong academic infrastructure and a long history of collaborative research activity between industry and universities.

10.2 Nevertheless, as Glaxo's business has grown and become increasingly global in recent years, much of the expansion of our R&D effort has taken place outside the UK. Fifty-one per cent of our sales are now in the USA and it clearly makes sense, therefore, for us to conduct research in that market and to establish a manufacturing base. Another main centre for research is in Italy. The main centres are supported by research undertaken in satellite groups located in a number of other countries including Japan, Italy, Canada, France, Switzerland, and Spain. Last year approximately half of our R&D expenditure of £323 million was spent outside the UK, and about one-third of our 5,000 R&D staff are employed overseas.

10.3 The factors which have determined this internationalisation of Research and Development include an intention to tap the talent and ingenuity available in the major developed countries, to harness a range of different cultures to the search for new medicines and to increase the research team's understanding of market characterisitics, by actually locating R&D in several major markets rather than centralising it in a single market.

10.4 The economic and political climate will also continue to be determining factors. As already stated in our response to question 6, pharmaceutical profit levels in the UK are controlled by the government through the PPRS. One of the aims of the PPRS is to promote a strong and profitable pharmaceutical industry in the UK capable of such sustained R&D expenditure as should lead to the future availability of new and improved medicines. The PPRS balances the needs of the government and the pharmaceutical industry in a flexible way and we believe that it is the only way forward in the foreseeable future.

10.5 In the past British companies tended, naturally, to conduct R&D in their home country. With the increasing internationalisation of the pharmaceutical industry and the restriction of those able to afford realistic research programmes to the world's major companies, the attractiveness of a home base is less obvious. As companies internationalise so their investment funds become more mobile. In this new situation, if the United Kingdom wishes to continue to attract and retain investment from global companies it has to consider how this should be achieved. It is possible therefore that attention needs to be given to whether the UK's current attractiveness is less than its historic importance. If so, then this historic importance seems set to decrease.

27 *June* 1990

Memorandum by ICI

SUMMARY

ICI is a science-based company, with a powerful commitment to research and development. In 1989, the company spent £639 million on R&D worldwide, of which 70 per cent, nearly £450 million, was spent in UK. Most of this money was spent not only on invention, but on "the economically significant application of new knowledge or techniques"—innovation.

The Select Committee's inquiry is important and timely. It is important because there is a general anxiety that Britain is falling behind its major competitors in Western Europe, USA and Japan, in industrial innovation, particularly in areas of new technology and high added value. It is timely because industry is presently faced with a great quantity of new legislation emanating both from Westminster and Brussels which, in their determination to control and protect, may unwittingly hamper innovation.

ICI has rarely felt in the past that the regulatory framework followed by successive British Governments has impeded its policy of innovation. There is no reason now to feel differently, except that on certain fronts, political pressures are building up which may cause the scientific approach to be overlooked. Environmental pressures are one kind of example; biotechnology is another. In either case, biased or uninformed social pressure may act as a barrier to innovation. Either may force manufacturing industry to look outside Britain, even outside Europe, for a new home more conducive to innovation, as some German companies have already been forced to do.

In the evidence which follows, ICI has taken each of the Committee's questions in their order of asking, but has occasionally chosen different examples to illustrate a point.

Briefly, the evidence covers:

(1) The view that short-term thinking, and short-term attitudes to profits, are inimical to innovation.

(2) The need for a broad approach to innovation. Acquisition a dynamic part of ICI's innovation strategy.

(3) Product development, while vital to ICI, often severely hindered by differing national regulations. Product engineering frequently vital.

(4) Conflicting priorities and cultures can delay innovation. Present systems, e.g., education, may jeopardize future innovation.

(5) Another aspect of short-term thinking—the value placed by the City on long-term innovation when valuing a company.

(6) Lack of knowledge creating difficulties in formulating legislation to cover new technologies.

(7) Having extensive links with HEIs, public laboratories, etc., ICI fears that universities' main responsibility, education, is being diminished by the need to earn money. Proper funding the only cure.

(8) Framework and Eureka Programmes—shortcomings.

(9) Crucial importance of suppliers and customers to innovation.

(10) Market needs determine location of innovation.

(11) Doubts about realisation of ACOST Report recommendations.

Q1 *What are the effects of company attitudes and structures (including personnel policies, investment decisions)?*

Expenditure by manufacturing industry on innovation is substantially greater, probably by a factor of more than three, than expenditure on invention. The main concern of those manufacturing companies which engage in R&D on any sizeable scale is, therefore, the cost of innovation. Of ICI's total R&D outlay of £639 million in 1989, it is likely that around £500 million was spent on innovation with over 70 per cent of the expenditure being in the UK.

While there is evidence that the UK's history of invention is second to none, its record on innovation in manufacturing over the last 25 years is poor in comparison with major competitor countries and has been in relative decline since about the mid-1960s. There are many related reasons for the weak UK performance on innovation and it is difficult to isolate the effects of company structures and attitudes. Moreover, a distinction needs to be made between the factors influencing innovation in different sectors of manufacturing.

Investment in innovation is essentially a long-term and risky activity but outlays on innovation do have an immediate and negative impact on corporate profits. Companies have, therefore, to balance continually the perceived short-term requirements of shareholders against the potential longer-term benefits of innovating. The low proportion of expenditure on innovation relative to sales and profit over a long period suggest strongly that, for the bulk of UK manufacturing, short-term attitudes to profits have generally prevailed.

While there does not appear to be any hard evidence, trends in expenditure by larger firms suggest that companies with strong centrally and financially controlled structures take a shorter-term view of innovation than do companies with more diverse structures. To some extent, the different attitudes and performance in innovation of the UK's chemistry, physics and biology-based companies seem to reflect different corporate structures.

Q2 *How active are UK companies in seeking out external technology, especially from overseas? How well do they adapt and apply it?*

Research and technology are the lifeblood of a science group like ICI. In the 1980s ICI spent over £3,000 million on innovation and technical service. Furthermore, since ICI was incorporated in 1926 its scientists have registered over 150,000 patents, and produced some 33,000 inventions, many of which are world leaders.

However, even major companies must be selective in what they take on, and their scientists can rarely be "programmed" to innovate to a particular specification on a given date. Consequently, in order to optimise the contribution of ICI's marketing and selling operations which have been built up in over 150 countries, most of the businesses seek to supplement the output of internal research with products or processes licensed from other companies or individuals. Thus, product acquisition groups are a dynamic feature of many of ICI's businesses and are expertly supported by information groups which can professionally interface with the world's literature.

Success in this activity is easy to exemplify. However, alongside each success story there are inevitably failures, some associated with competitors outpacing ICI, or being prepared to pay more for the innovation than ICI deems appropriate, and some resulting from products not fulfilling their expectations in the market place.

Notable UK successes for ICI include nylon, which was licensed by ICI in 1940, the synthetic pyrethroids, which were discovered at the Rothamstead Experimental Station and patented by the UK National Research Development Council, and, most recently, the DNA fingerprinting diagnostic technique, which was invented by Professor Alec Jeffreys at Leicester in 1984, patented by the "Lister Institute of Preventive Medicine", of which Jeffreys is a Research Fellow, and marketed as a complete service by ICI Cellmark within one year of the license agreement being signed.

Other examples illustrate the importance of product acquisition on an international basis. ICI Agrochemicals' highly successful herbicide "Fusilade" was invented independently both by ICI and a Japanese company; the latter was first to patent. By acting swiftly, ICI was able to conclude an exclusive product agreement in an area of international significance to ICI.

ICI Pharmaceuticals is also actively involved in Japan and twice each year sends a senior acquisition team to Japan to discuss possible opportunities with Japanese pharmaceutical companies. One product was obtained at a late stage of development and is now on sale and recently a research and development collaboration was successfully concluded and the compound is in the final stages of clinical evaluation. If this is concluded satisfactorily, ICI Pharmaceuticals will market the product in all territories outside Japan and South East Asia. ICI Pharmaceuticals has also successfully licensed novel products from Europe and the USA.

Lastly, ICI has benefited from product exchanges. Perhaps one of the most successful has been the exchange between the Company and the American Merck & Co of "Statil", a diabetes therapy drug, and "Zestril", a hypertension and heart failure product.

Thus, the ICI Businesses recognise the need to acquire products from the UK and overseas to fill product gaps associated with misfortunes or miscalculations in its internal research programmes.

The key requirements for successful product acquisition are:

- A business strategy which defines the need and which is regularly updated.
- A comprehensive data base which can define which companies might be in a position to satisfy the need.
- A skilled, knowledgeable and dynamic product acquisition group which can be quickly fortified with senior people as and when required.
- A development system which attaches just as much importance to an acquired product as it does to the products from its own research.

There is no plea for help in this aspect of our business activities. It is up to us to get it right. Some 15 years ago we were worried about the bureaucracy and uncertainty of notifying our intentions for collaboration with the European Community. We still have to notify when appropriate but no longer feel that notification is threatening to a potentially useful collaboration.

Q3 *What are the respective roles played by product development and production engineering in technological innovation?*

Product development and production engineering are of crucial importance in all facets of ICI's business. However, there are differences in emphasis depending on whether the innovation is in Agrochemicals/Pharmaceuticals or Commodity/Industrial Chemicals. In the former, the time needed to turn an invention into a marketable product can be between six and 12 years or more, and involve expenditure of many millions of pounds. Expenditure on the development of a new ethical drug can exceed £100 million. This length of time and level of expenditure are required to complete safety evaluation, formulation development, process development, clinical/field testing and compilation of the documentation which has to be submitted for approval.

Most of the work is prescribed by government regulatory agencies, and requirements can differ from country to country. This is irritating and wasteful and much effort is expended by industry, usually through its trade associations, to encourage the international harmonisation of regulations. When help has been sought from government departments it has been given.

Production engineering can be of crucial importance in Pharmaceuticals/Agrochemicals. For example, ICI Pharmaceuticals recently launched a treatment for prostatic cancer which required a polypeptide to be incorporated into a bio-degradable polymer, to enable one dose to be injected each month. The production engineering problems which had to be solved were formidable. More so, because the final form had to be sterile.

In those businessess concerned with commodity products and bulk chemicals, the quality and speed of response of the production engineering function can be crucial to the success or failure of the product in the market place. For example, the replacement of CFCs is in effect a race between major chemical multinationals to develop products and design manufacturing processes and plants in order to sieze leadership in this new market. The company with the most effective product development and production engineering capability will probably pick up the lion's share.

The petrochemicals business provides many good examples. In such a capital intensive area, what frequently enables a company to grow faster than competitors (and thus preferentially grasp the benefits of scale) is the ability to get more product out of less capital—almost entirely a function of one's production engineering capability.

The production engineer is therefore critical to ICI's continuing success in this country. It is particularly worrying that demographic trends, and the national perception of engineering as almost a second class career, are making the recruitment and retention of good engineers increasingly difficult.

Q4 *How effective are the activities of Government departments in promoting and supporting innovation?*

ICI has frequent and continuing contact with most Government departments. Much of this contact takes the form of the exchange of information, and broadly ICI feels that the Civil Service tries to support what the Company is trying to achieve. Sometimes, however, and in certain areas, there are difficulties, which can be due to differences in priorities or cultures. Below, we cover some of these difficulties.

(i) *Product Approvals*

To bring a new product to the market, ICI depends not only upon its innovatory skills, but frequently upon approval from Government departments. This applies particularly to agrochemicals and pharmaceuticals.

In these two areas, the development time has inevitably been long, mainly due to product testing. In fact, we can be talking of a lead time of more than 10 years, during which of course there is great expenditure but no income from the product. Still, however, the product's patent life is ticking away.

All new pesticides and herbicides are finally subject to MAFF testing and approval. It is extremely worrying that new products, even after ICI's own rigorous internal testing, are presently subject to delays in MAFF testing of an average four years. Only seven British products have been tested by MAFF during the year that has elapsed since the Ministry announced a review of its system, leaving some 300 products still to be tested and approved. Even though the Minister has recently announced an increase in MAFF's testing capacity, still years will elapse before the backlog of new products, and the review of old, is completed.

In the field of pharmaceuticals, it would be premature to judge the Medicines Control Agency. As yet we have no experience of seeking approval for a newly-developed product. However, what contacts we have had with the MCA leads us to expect a prompt and efficient response.

(ii) *Patent Term Restoration*

As mentioned in 6(i), in many cases a large part of a development product's patent life has expired before it ever reaches the market and starts to recoup its development costs. Some pharmaceuticals can be 12 years into their 20-year patent life before they start earning.

A new ethical drug has probably over £100 million to recover before it truly becomes profitable. During the debate on the Copyright, Designs and Patents Act, in the case of both pharmaceuticals and agrochemicals, the DTI was greatly supportive, and helped to establish an exemption for these two product types from Licences of Right, which for other products automatically allows other producers, on payment of a royalty, to use the patent as soon as it has run for 16 years.

Nevertheless, there is a case for further protection. While a product like a new drug or pesticide, which are both subject to legal constraints, is still in the development stage, and therefore incapable of being sold, there is an argument for some form of technical protection before the patent life proper begins, simply because, with a 12-year development period, a product's actual patent life is not the putative 20 years, but eight. There is some Government sympathy with this difficulty, which ICI hopes will turn into active support. Restoration of true patent life is vital for healthy innovation.

(iii) *Education—Science and Engineering*

Though the subject of Education is to some extent covered in the answer to Question 7, there is another point to be made here.

The future of innovation in the chemical industry, and therefore in ICI, depends on the education of our young people in Science and Engineering. Successful innovation comes from well-trained minds.

It has been pointed out many times that the sciences and engineering—the difficult subjects—are not widely or well enough taught in British schools. This is not the place to analyse why this should be, except to say that education, it seems to us, is a prime responsibility of Government, and it is up to Government and its Civil Servants in DES to develop the necessary organisation and rewards to stimulate pupils so that they can achieve higher standards. This is not happening. Science, and more particularly engineering, are held in low esteem. By and large, Civil Servants, however well-educated, are not scientifically trained, and have little sympathy with science, nor understanding of the contribution scientific innovation makes to the national economy.

In the meantime, the number and quality of science teachers decline; so does the number of school leavers wanting to follow a scientific career. Equally, fewer graduates want to teach science. The situation, it seems, is going to get worse before it can possibly improve, though it may be ameliorated by greater support for teachers—technician assistance, equipment and teaching media.

(iv) *Genetically Modified Organisms*

Biotechnology, perhaps more than any other current technology in manufacturing, must qualify as innovatory. For this reason, it is reasonable to judge the Government's attitude to it, and so the activities of Government departments. It must be said at the same time that British shortcomings are generally less than those of some other European countries, or indeed of the European Commission as a whole. What they have in common is an apparent blindness to the likely effect on research and innovation in Britain of what looks to be a policy of hindrance and delay in the face of a much more encouraging approach by our principal competitors in the USA and Japan.

This subject is covered in some detail in our response to Question 6.

Q5 *What are the effects of city attitudes to investment in innovation?*

Financial markets are characterised by practices which are inimical to decisions to invest in innovation. This is largely because of the uncertainty about innovation and information flows which are mostly inadequate. Not only are potential returns from innovation extremely difficult to measure but there are other problems such as monitoring performance over time which City institutions have not really overcome. As a consequence innovating firms even though they themselves may contribute to information failures, become risk-averse.

The information failures are widely believed in industry to contribute to so-called short-termism. Companies anxious to satisfy City opinion on profits and dividends in the short-term often reduce expenditures on innovation, although innovation can result in an improved financial performance over the longer-term. Such pressures on companies are particularly strong if a company perceives itself to be a potential take-over target.

Q6 *What is the effect of the legislative and regulatory framework concerning for example labour costs, patent laws and tax concessions on R&D and the purchase of know-how?*
Inevitably, ICI's business, because of its size and variety, is ruled by a farrago of laws and regulations. Employment, patents, trademarks, terms of sale, health and safety—the list is endless—are all protected or restricted by law. What ICI seeks is reasonable law, law influenced by the needs of the chemical industry, but not designed specifically for it.

Some innovation involves new developments in existing technology. In such cases, it is quite likely that the technology is covered by some aspect of the law, and it is equally likely that the law is reasonable—or that the Company has learned to live with it.

Innovation within a new technology is almost certainly different. Here, it is quite possible that an appropriate legal framework does not exist, and so it must be created. This is extremely difficult, because the technology itself is breaking new ground, and the response to it may well be emotional rather than logical or scientific.

A good example is Biotechnology.

The Environmental Protection Bill presently going through its various stages in Westminster gives ICI great cause for concern. In the first place, we cannot understand why Genetically Modified Organisms, (or Biotechnology), have been included in the Bill at all. The fact that they are implies *a priori* that biotechnology is dangerous. This does not seem reasonable to us. Biotechnology after all is simply a range of precise techniques for doing what nature has been slowly doing for itself since the beginning, or what man has achieved through fermentation and hybridisation. Suddenly, this Bill is about to categorize and treat biotechnology as environmentally hazardous.

Having done this, the Bill, once it passes into law, may restrict innovation in biotechnology, for example:

Under the controls covering Deliberate Release, it may hinder quite basic development work through a system of consents and permits. In the case of seasonal crops, for example, delay in granting a permit for trial planting may force postponement of the trial for at least a year. In the case of pesticides comprising GMOs, all testing may be prevented because the product harms some living organisms, which in terms of the Bill's definitions includes pests harmful in themselves.

Because of the Bill's overall requirement for public access to information, any open-air crop trial may be jeopardized because a pressure group or a vandal can discover its location, and try to wreck it (this is actually happening in West Germany, where a small plot of begonias must be constantly guarded against environmentalists day and night). In ICI's case, no release of an innovation in biotechnology would be made at all before extensive safety testing had been completed in contained laboratory conditions. Deliberate release would be the natural culmination of that testing.

The Secretary of State for the Environment, speaking of the publication of information, as outlined in the Bill, recently told the Chemical Industries Association that he foresees few cases where confidentiality would need to be preserved. At present, there are few development products emerging, and each can be treated individually. In a few years time, the trickle will become a flood. A multitide of developments will be emerging, and there will be little chance of each being treated on its own as far as, say, commercial confidentiality is concerned. At that time it will be essential that we operate within a legislation that encourages innovation in biotechnology.

It is not that ICI wants to avoid the regulation of biotechnology. Quite the reverse: we are strongly in favour of proper regulation, since apart from its social benefits, it allows us and everybody else to enjoy level playing fields. But we prefer to see regulation that does not discriminate irrationally, even unfairly, against the use of biotechnology or any other innovatory technology, but applies the normal criteria of safety in manufacture and use, and efficacy. Reasonable legislation encourages fair competition, and prevents unfair competition by irresponsible companies who cut costs by ignoring safety precautions. Equally, legislation means that ICI's activities in biotechnology will be seen to be properly regulated, and the public will be reassured about the safety of both the processes and the products in this important field of innovation.

Q7 *How effective are the mechanisms for technology transfer from HEIs, Research Councils and public laboratories to manufacturing industries?*
Our main experience has been with universities and Research Council laboratories. We interact with other "public laboratories", e.g., Harwell, Warren Spring Laboratory, etc., to a much lesser extent.

Like most others in the chemical and associated industries who are science based, we rely on HEIs, especially universities more as a source of educated people at all levels than as a direct source of "invention".

However, if innovation is here defined as the "economically significant application of new knowledge or techniques" then almost all of this new knowledge and these new techniques originate in academy and it is we in industry who try to make the "economically significant applications". Only rarely do we find, or are we offered, from academy anything new which is in a state directly suited for "economically significant application". On those rare occasions when this has happened, e.g., the "genetic fingerprinting" technique from Alec Jeffreys at Leicester University, the technology transfer has mostly been quick and smooth with few problems.

In seeking new knowledge and techniques, and of course in recruiting able youngsters to join us so that we may apply this technical novelty, we have detailed and extensive interactions with most universities in this country and many overseas. These interactions, as we have remarked to your committees and numerous others, are mostly useful, effective, and friendly. The best are invaluable. A key step in the process is an awareness on both sides of each parties' interests and expectations, both scientific and commercial. Mostly this comes from the customary interactions of the scientific community, publication, meeting attendance, etc. Databases and publications outlining academic interests are very helpful to us, especially BEST which should be strengthened and to which all technical academics should be urged to contribute.

Universities, especially in this country, are being urged to do all they can to help industry. In some faculties, notably those of chemistry and chemical engineering, close interaction with industry has, happily, been the custom. Unfortunately the present priority given to this activity stems more from a desperate need to raise funds than from any natural extension of academic interest. One beneficial result of this trend has been the setting up in almost all UK universities of Industrial Liaison Offices which are useful contact points for those seeking help on either side. It is important for these to be properly funded and to have sufficient authority within the university to ensure that any collaborations are properly managed. Having said that we must emphasise that, in our view, the primary job of academy is education and that earning money should be a secondary and minor activity. The present emphasis is wrong and if continued will diminish the capacity for education, scholarship and research which are for us, the universities main contribution to the overall process of innovation. The goose that lays the golden eggs is being killed.

Our interactions with Research Councils are of a similar character to those we have with universities, indeed we see them as our main partners in fostering education, scholarship and research in universities. The SERC in particular by their CASE and co-operative grant schemes have allowed us to influence and selectively support areas of science which we hold to be of unusual importance in the earliest parts of the innovatory cascade. The other Research Councils are, to varying degrees, following suit. We also have several major collaborations with SERC and MRC laboratories costing in all several hundred thousand pounds. These have been fruitful, friendly and well managed by both parties.

Q8 *Does the UK benefit sufficiently from EC support for innovation? How might it be improved?*
Generally, Britain has done quite well from EC support for innovation, through Framework and Eureka. ICI has projects running under both schemes.

Some constructive criticism can be levelled at Framework. ICI has found that its structure is too rigid, and too often projects have to be tailored or even distorted to fit in with Framework's programmes. Also, it is slow, because it is not a truly ongoing programme, rather a sporadic one—projects can only be submitted on a biennial basis, and then it takes another two years for acceptance. A further problem is that the project detail required in a Framework application is so great that it can actually consume an unacceptably high proportion of the funds sought. Each of these problems contributed to the failure of the Dante Project (Electronic Microscope), vitally important to the chemical industry, to fit the Framework Programme. Making an application to Framework is like buying a lottery ticket.

Eureka with its input from government, countries and companies, has much more flexibility than Framework.

A peculiarly British problem with these European programmes is that while, say, France separates Eureka, and Framework in funding terms, the UK has only one kitty, held by the DTI, and the more that goes into one programme, the less goes into the other. And again unlike France, where the Government generally takes a stake in the project, the British Government seems uninterested in sharing any of the risk associated with innovation.

Q9 *What are the effects of the varying relationships between companies and their suppliers?*
At some point, any innovation of ICI's, once it has reached a certain stage of development, must be tested in the real world of suppliers and customers. New products inevitably need changes in production equipment, production services or raw materials. To develop any new product, ICI will almost certainly look for some input from suppliers, in the form of new equipment, for example, designed to ICI's specification or requirement. So good relationships and open access to our suppliers are essential.

In turn, ICI is a supplier to its customers, but obviously on a quite different footing to its own suppliers. Without customers, no innovation, however interesting to ICI, can succeed.

In short, it is the customer, or the market, which largely determines what development ICI should be doing, and where the Company's innovative effort should be directed. Therefore, the relationship with the customer must more than anything else be based upon a true understanding of market needs.

Q10 *What factors influence decisions to invest in innovation in the UK or overseas?*
Two factors mainly influence the location of innovation in the UK and overseas; the relative costs of innovation and the requirements of the market to be served.

The UK has a cost advantage over many countries in innovation and this is a powerful inducement to base such activity in the UK. Against this, however, it is necessary to balance this cost advantage with the need to be on the ground in particular markets. It is often difficult, for example, to meet the emerging product needs of US and Japanese customers from a UK base so that some investment abroad is necessary. A related issue is that the main sources of technology in some fields are in the US and Japan which, to gain access to, necessitates a presence in those markets.

Q11 *In the light of ACOST's report "Defence R&D: A National Resource", and the Government's response, is there a satisfactory relationship between the defence and civil sectors?*
Some of the most important recommendations made in the ACOST Report were:

- The need to make better use of civil technology.
- The need to undertake as much R&D as possible in the civil sector.
- Retention of critical elements of defence R&D, in which there will never be much civil interest, within the defence establishments.
- The creation of a more suitable relationship between defence and civil R&D.

As a result of the Report and other initiatives, a major re-organisation of the Defence Research Laboratories is underway, and the creation of a "Defence Research Agency" is expected in April 1991.

It is by no means certain that this proposed Agency will meet the ACOST recommendations. Two questions about the Agency's remit have still to be settled:

- Will the Agency compete with industry for R&D funds?
- Who will assess technology proposals?

The principal aim of the re-organisation appears to be to achieve economies in national defence spending. ICI hopes that this search for economies will not be at the expense of constructive collaboration with industry, and continuing enhancement of the technology base in British industry.

10 *May* 1990

Memorandum by the Inland Revenue

INTRODUCTION

1. Expenditure on machinery and plant in the UK may qualify for tax relief in one of three ways:
   (a) By writing off the expenditure at 25 per cent on the reducing balance basis.
   (b) By electing for the short-life regime so that the cost can be written off more quickly when the asset is sold or scrapped.
   (c) By writing off 100 per cent of the cost immediately where the asset is used for "scientific research".

2. The system took its present form as a result of the business tax reforms of 1984. The aim of those reforms was to make investment decisions more neutral. This was done by removing special tax reliefs and using the revenue to reduce the main rate of corporation tax from 52 per cent to 35 per cent. In particular, the rates of allowance for capital expenditure were reduced to bring them more closely into line with commercial depreciation.

3. Until 1984 most expenditure on machinery and plant qualified for immediate 100 per cent first-year allowances. Such high rates of allowance could distort investment decisions and encourage poor quality investment. Because the tax allowances greatly exceeded the economic rate of depreciation it was possible for an investment project to yield a negative rate of return before tax and to yield a positive rate of return after tax.

4. Individual firms will generally base their investment decisions on the yield of a project after tax. But, from the point of view of the nation as a whole, it is the total rate of return *before* tax on investment that matters. Poor quality investment could yield a good return to the investor before 1984 because the Exchequer was providing a subsidy through the tax system; yet it would not be the best use of scarce resources for the nation as a whole.

5. Interest paid on borrowings used to finance business assets was allowable in full before 1984 and has continued to be allowable since.

25 per cent rate of allowance for machinery and plant

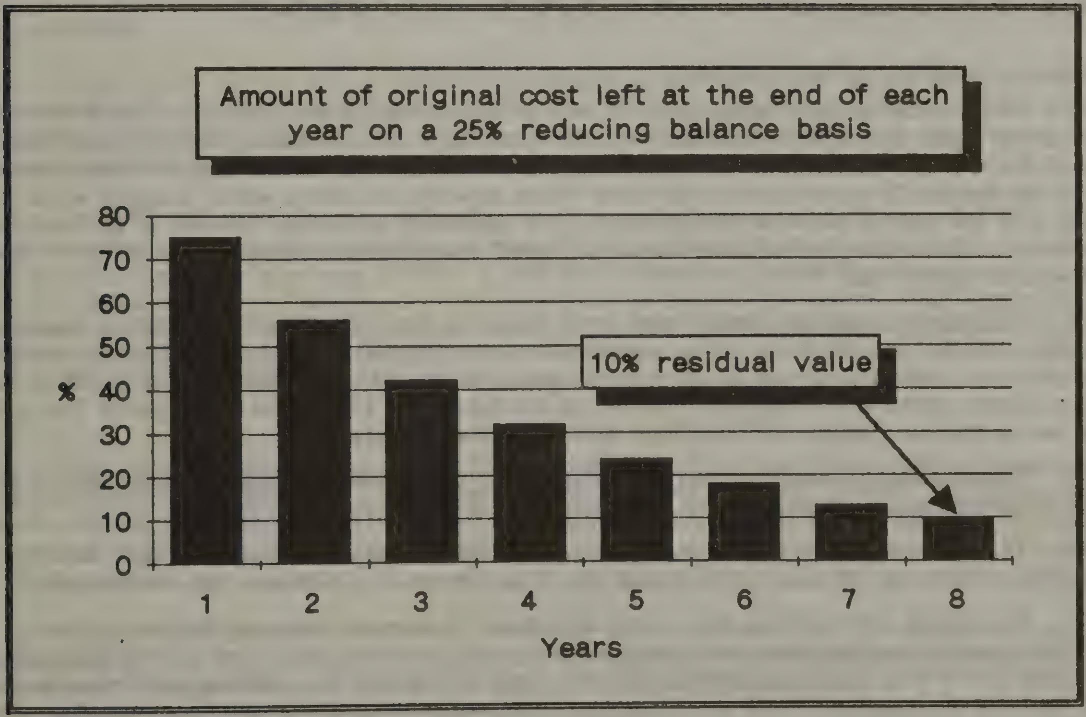
6. If writing down allowances were to reflect true depreciation, then in theory individual rates of tax depreciation allowance should be tailored to each type of asset and to the circumstances in which the asset is used. For example, ships and aircraft tend to have lives of 15 to 20 years whereas delivery vans might only last two or three years. And there may also be great variations in the rate of use of the same type of asset (single or double shift working) and in the effects of technical obsolescence (a computer may need rapid replacement in one business but serve satisfactorily for years in another).

7. The tax depreciation profile would also need to reflect the actual rate of economic depreciation. Assets do not usually depreciate in equal annual instalments over their working lives; the depreciation is often greatest in the first year and it then tails away in a curve which gradually flattens out. The capital allowance reducing balance basis tries to match this curve by giving larger allowances in the early years of an asset's life. This produces a curve in the amount of unrelieved expenditure.

8. For 25 years after the last War the UK had a system which aimed to deal with assets on an individual basis and to cater for individual circumstances. To a greater or lesser extent this is what many other countries still do. Inevitably, the more refined the system the more complex and costly it is to operate for taxpayers and Revenue. There is obviously considerable scope for argument at the margins about asset life and the impact of exceptional factors. And the more rates the system has the more computations are needed.

9. As explained in paragraph 2, the abolition of accelerated tax depreciation for machinery and plant (together with the abolition of stock relief) enabled the Government to reduce the main rate of corporation tax from 52 per cent to 35 per cent. As part of the Budget package, the Government decided to adopt a single rate of 25 per cent as an average rate of depreciation for all machinery and plant. This allows about 90 per cent of the cost of an asset to be written off for tax over eight years. The remaining 10 per cent will often approximate to the scrap value and it continues to be written off in succeeding years.

10. The following Chart shows how expenditure is relieved and how the capital allowances at 25 per cent are front-loaded by the reducing balance basis. (The equivalent straight line rate would be 11.25 per cent a year for eight years.)



11. By having a single rate of allowance it is possible to simplify tax computations. Most expenditure on machinery and plant goes into a single pool and the 25 per cent allowance is given on the net aggregate balance (that is, after adding new expenditure and deducting the proceeds of disposals). There is no need to consider how long particular assets may last and, in most cases, no need for individual computations for each type of asset.

12. In practice, the UK's 25 per cent rate reflects a generous assumption about average asset lives if, as may be reasonable, the average scrap value of assets at the end of their useful life is 10 per cent. The available evidence suggests that the actual average life of UK machinery and plant is nearer 20 years than eight. The

Central Statistical Office assume an average life of over 20 years. American work indicates that the average life of machinery and plant in the USA may be around 17 years. A 17-year life implies a reducing balance rate of a little over 12 per cent.

13. In addition, unlike most countries, the UK gives a full 25 per cent allowance for the first year. In principle, the allowance for the year an asset is purchased should be time-apportioned to reflect the actual period of ownership; so an asset bought on the last day of the tax year should, in theory, qualify for hardly any allowances at all. But, in order to keep the system simple, the UK does not time-apportion. In practice, therefore, the allowances in the first year of ownership can be as much as 44 per cent of cost where an asset in bought just before the start of the year (i.e., the sum of the first two year's allowances). It follows that the effective write off period falls somewhere between seven and eight years.

14. An example may help to show how the present UK system impacts on the rate of return. Since the Committee are specifically concerned about high interest rates the example looks at the case of debt financed investment. Assume:

(a) A company aims to achieve a real rate of return on investment of 8 per cent.
(b) Inflation is running at 5 per cent.
(c) The life of the asset is 17 years (the average life suggested by the American work).
(d) The investment is financed by borrowing at market rates of interest.
(e) The corporation tax rate is 35 per cent.
(f) The asset is purchased at the *start* of the first year (i.e., there is a full year's economic depreciation in the first year so that *no* advantage is gained from the generous first year rule).

15. On those facts the investment project need only yield a pre-tax rate of return of 5.1 per cent in order to generate a post-tax real rate of return of 8 per cent to the company. This is because the tax depreciation allowances of 25 per cent exceed the economic depreciation suffered and therefore contain an element of subsidy.

16. Further, because the full nominal amount of interest on the borrowing is deductible in computing taxable profits, the system contains built-in protection against inflation for debt financed investment. In fact, the pre-tax rate of return required to yield a real return of 8 per cent falls as inflation rises. For example, if inflation were 10 per cent, a pre-tax return of 3.5 per cent is required to yield a real post-tax return of 8 per cent. This is because nominal interest rates generally rise as inflation rises and part of the interest payment represents compensation to the lender for the fall in value of the loan.

Short-life regime for machinery and plant

17. The short-life regime was introduced in 1985 to give further help for assets with a life of five years or less. The regime avoids the considerable problem of defining a short-life asset by allowing most assets to qualify for short-life treatment at the taxpayer's option. This is possible because short-life assets continue to get the standard 25 per cent rate of allowance. Where, however, the asset is sold or scrapped within four years after the year of purchase, the taxpayer gets a deduction for the full amount of the unallowed depreciation. This is not possible under the normal "pool" system because expenditure on individual assets is lost in the global total.

18. For example, suppose a heavily used van is bought in Year 1 for £10,000 and sold in Year 2 for £4,000. In the first year the trader will get capital allowances of £2,500 (£10,000 @ 25 per cent). Assuming that the trader nominates the van for short-life treatment, he will get capital allowances of £3,500 in Year 2, (i.e., the tax written down value of £7,500 less the sale proceeds of £4,000). So, by the end of Year 2, the full loss on the van—£6,000—will have been allowed for tax purposes.

19. Where an asset is not sold or scrapped within the five-year period, the remaining unallowed cost goes into the general capital allowances pool and continues to get allowances at 25 per cent.

20. The net result is that rapidly depreciating assets can get full relief on disposal and there are no arguments about asset life because the annual rate of tax depreciation allowance does not change.

21. By contrast, if the trader in the example did not opt for short-life treatment for the van, the cost of £10,000 would go into the general machinery and plant pool. The allowance in Year 1 would effectively be the same. But in Year 2 the sale proceeds of £4,000 would be deducted from the balance of expenditure in the pool and the remaining £3,500 would continue to be written off at 25 per cent over succeeding years.

Scientific Research Allowance and Enterprise Zones

22. The Government decided to make an exception for scientific research expenditure when accelerated capital allowances were generally abolished in 1984. Hence capital expenditure on activities directed at the extension of knowledge in the fields of natural or applied science continues to qualify for 100 per cent allowances. The 100 per cent relief is not due for near-market development expenditure or for market research expenditure.

23. Industrial and commercial buildings in Enterprise Zones also continue to qualify for 100 per cent allowances.

Other countries

24. Simple comparisons can be misleading but, in general, because other countries have a wider range of rates than the UK, they will tend to offer higher rates than the UK for assets with a life of less than eight years and, conversely, lower rates for assets with a life of more than eight years. In the UK, as already noted, the short-life regime caters separately for rapidly depreciating assets by giving a tax deduction for the unrelieved depreciation on disposal.

25. It also needs to be borne in mind when making comparisons that the UK has one of the lowest rates of company taxation amongst our main competitors. The main UK rate is 35 per cent and there is a lower rate of 25 per cent where profits are under £200,000. (There is also a marginal band where profits are between £200,000 and £1 million.) By contrast the general German rate is 50 per cent (36 per cent on distributed profits) and the Japanese main rate is 37.5 per cent with a lower rate of 28 per cent.

26. Brief notes on the German and Japanese tax depreciation regimes are set out below.

Germany

27. There are over 90 official tables of depreciation rates covering all types of business. Individual rates can be negotiated where this is reasonable and extra allowances can be claimed where there is unusual wear and tear or assets become obsolete for economic or technical reasons. The overall objective is to write off expenditure over the expected life of the asset.

28. The maximum rate of reducing balance allowance is 30 per cent.

29. In addition, Germany has some incentives rates of allowances for designated areas (such as the Saar coal mining area) and for investment in, for example, certain sources of energy.

30. Germany has provisions for time-apportioning the allowances due in the first year.

31. R&D expenditure may qualify for accelerated depreciation allowances of up to 50 per cent of cost spread over five years (but, overall, the maximum relief under the normal and accelerated systems is limited to the actual cost). Germany also has a system of grants which are directed primarily at small and medium sized enterprises.

32. Comparisons with the UK are not straightforward because the overall impact of quite different regimes is difficult to assess. A 1987 UK study concluded that the net impact of fiscal reliefs for R&D in both countries was broadly the same for larger companies but that the German system of grants provided more incentives for small and medium sized companies.

33. The 1987 UK study also reviewed other work on cost-effectiveness which suggested that R&D incentives, of a variety of kinds, stimulated additional R&D spending amounting to only about one half of their cost to governments in revenue forgone. A later Australian study, published at the end of 1989, has come to a similar conclusion. The Australians offered a deduction equal to 150 per cent of R&D expenditure. The Australian Bureau of Industry Economics found that the relief had cost the Australian taxpayer Aus $4 for every Aus $1 of new spending on R&D.

Japan

34. Japan also bases its tax depreciation rates on asset lives. There are a large number of published declining balance rates. These range from 14.2 per cent for steel furniture to 43.8 per cent for forklift trucks. Variations can be negotiated where assets wear out abnormally quickly. There are also incentive allowances for various kinds of investment; for example, assets used in energy supply, recycling or in certain development areas.

35. The allowances due for the first year of ownership are time-apportioned. The taxpayer can usually elect to adopt a "half-year convention" for the year of purchase; that is, to be treated as if he acquired his assets halfway through the year so that he gets half the allowances otherwise due.

36. Japan has a fairly complex system of tax credit reliefs for research and development expenditure. These credits are given in addition to the normal depreciation deductions. Under a credit system the relief is given as a deduction from the tax due (and, in some cases, any excess may be paid to the business) and not, as in the UK, as a deduction in arriving at taxable profits.

37. There are two main components in the Japanese system.

38. First, where R&D expenditure is increasing, the trader can claim a credit of 20 per cent of the extra expenditure up to a limit of 10 per cent of the tax bill before the credit. Second, research in basic technology may qualify for a further credit of 7 per cent up to a limit of 15 per cent of the tax bill before the credit.

Where the taxpayer qualifies for both types of credit the maximum combined deduction is limited to 15 per cent of the tax bill before the credit is allowed. In addition, there may also be help available outside the tax system in the form of soft loans.

39. It is very difficult to make comparisons but the 1987 study concluded that the net impact of the Japanese fiscal reliefs for R&D were broadly the same as those of the UK.

Possible changes in capital allowance rates

40. The rates of corporation tax and capital allowances are reviewed each year as part of the Chancellor's Budget judgment alongside other aspects of business taxation. In general the Government aims to keep the tax environment in which business makes investment decisions as stable as possible.

November 1990

Memorandum by the Institution of Production Engineers

SUMMARY

Evidence has been collected from within the Institution of Production Engineers in response to the enquiry from the House of Lords Select Committee on Science and Technology into "Innovation in Manufacturing Industry".

Considerable concern has been expressed on the subject of the pursuit of innovation in manufacturing industry. The Institution's view is that a resurgence of manufacturing industry is vital to this country's needs in the face of declining revenues from North Sea Oil, intensive competition from the Far East and widening markets within Europe after 1992.

In particular, the Institution makes the following points:

1. City requirements for short-term profitability preclude the establishment of an innovative culture and significant investment in product and process development.
2. Rigid organisation structures within companies inhibit a multi-disciplinary approach to innovation.
3. Education and training are not focused on industry's long-term needs.
4. Technology transfer from Higher Education Institutions, the Defence Sector and Institutes to industry is running at too low a level.
5. Government programmes to help companies are limited and could be more effective.
6. Awareness of EC programmes is insufficient and excessive bureaucracy inhibits participation.
7. Companies are not taking an integrated stance with their suppliers and customers. Formal structures to assess and implement new ideas are not prevalent.
8. New co-operative ventures such as Teaching Company Schemes and Link Programmes are to be encouraged.

FOREWARD

The Institution of Production Engineers is a professional body incorporated by Royal Charter. Its Charter objectives are in the areas of manufacturing management and technology. The Royal Charter definition of a production engineer is:

> "One who by reason of education, training and experience in technology and management is competent to determine the factors involved in the manufacture of commodities and to direct the production processes to achieve the most efficient co-ordination of effort with due consideration to quantity, quality and cost."

Therefore the Institution is a highly qualified body to contribute objective proposals on any initiative considered suitable for the furtherance of innovation in British industry.

BACKGROUND TO THE INSTITUTION'S SUBMISSION

The Institution has a Technical Policy Board which has overall authority for a number of committees, activity groups and working parties. Currently, over 150 members are engaged in activities aimed at generally promoting manufacturing management and technology in the British manufacturing industry.

Specifically, the Institution has been addressing the problem of implementation of innovation in manufacturing industry through members' participation in its working party on "Product Innovation and Strategy". Over the last three years, the working party members have researched the topic and considered the views of industrialists through a series of national and regional seminars entitled "Where Next?"

The strong foundation of this working party has been used by the Institution to gain further evidence from leading industrialists and educationalists to answer the specific questions of the Select Committee.

The Institution is convinced of the essential need for active and effective innovation if UK manufacturing industry is to reverse the unsatisfactory trend in its share of world exports experienced in recent years.

DEFINITIONS

The Institution of Production Engineers has collected evidence from a cross-section of its members before making a response to the Select Committee established:

"To consider the pursuit of innovation in manufacturing industry".

A submission of comments is made herein to the eleven questions posed by the House of Lords Select Committee on Science and Technology Sub-Committee I—Innovation in Manufacturing Industry.

The enquiries were made using the Select Committee's statement that innovation is distinct from invention and that innovation is defined as:

"Economically significant application of new knowledge or techniques."

Q1 *What are the effects of company attitudes and structures?*
The Institution believes that company structures are the prime limiting factor to innovation in UK companies. It is seen that many UK companies have no formal structure for identifying and implementing new ideas. This lack of structure restricts companies to reactive actions, rather than advancing with a proactive approach to new ideas.

In general many large companies are seen to be exercising extreme caution leading to a prudent approach to innovation. Many such British companies no longer take risks as they used to. This policy has led to few British companies being world leaders.

The Institution believes that one of the causes for the retention of rigid company structures and a general reluctance to break them down is the high degree of specialisation in the education of recruits from the British higher education system. In comparison, Japan educates on a broad base and Japanese industry provides the specialist training it requires. British industrial training is seen to be old-fashioned in nature and off-line in style, resulting in out-of-date practices which are not in tune with the world's best practices.

There is a wide concern that British manufacturing industry is being pressurised into short-term thinking and required to "make money by saving money". Shareholder pressure is seen to be limiting investment to areas where quick returns are attainable.

Personnel policies are believed to have an adverse effect on recruitment of people who support innovation. The effect is seen to be a lack of professionals and professionalism in British companies to create a manufacturing culture to support innovation. The manufacturing cultures of Japan and Germany are cited as goals to which British companies should be striving.

Intolerance towards new ideas is leading to an unwillingness to air new ideas at all. British companies should be paying more attention to ideas and suggestions from their own work forces.

A positive commitment to change by senior management is required through the adoption of innovative ideas. Top management must give commitment and an emphasis to both product development and manufacturing systems engineering skills.

In the manufacturing environment, the operational activities take preference over, and to the detriment of, the structured development of manufacturing systems.

The Institution is encouraged to observe a start in the breakdown of traditional attitudes and structures with the introduction of Total Quality Management techniques and the Task Force approach.

Q2 *How active are UK companies in seeking out external technology, especially from overseas? How well do they adapt and apply it?*
The motor industry is given as a good example of an active British sector in the introduction of innovation. It is seen to be adapting and applying external technology successfully.

The Institution observes a serious lack of effort and commitment by small- and medium-sized companies to take new technology on board. It is observed that only small high-tech companies appear to cope with the absorption of new technology. The Institution suggests that the environment of continuous change in high-tech companies is the enabling factor.

Barriers to new technologies in small enterprises in the post 1992 Single Market are seen to be those of distance and language and strenuous efforts must be made to enter into client cultures.

Careful attention should be paid to competitors. The developments of competitors should be acknowledged as a further source of new ideas, along with those of suppliers. Customers and suppliers must be integrated into company strategies and classic functional barriers must be eroded.

The historic structure of senior management being over-specialised may be restricting the recognition of the potential of multi-disciplinary concepts.

In summary, a manufacturing business must now be considered as a total entity.

Q3 *What are the respective roles played by product development and production engineering in technological innovation?*
The Institution considers the roles to be by product development and manufacturing engineering, rather than production engineering, as they believe this better reflects modern thinking and current educational practice.

Traditional production engineering is over-specialised, has a narrow focus on the machine rather than the total manufacturing system, and fails to meet the Japanese challenge. There should be two clear roles alongside the product development role:

(a) Industrial Engineering.—Operational Engineering
(b) Manufacturing Systems Engineering—Development Engineering.

The former supports continuous improvements and the achievements of short-term targets. The latter provides a fundamental medium- to long-term development capability.

Little involvement of manufacturing systems engineers is observed throughout the whole product development cycle. It is noted that this is especially prevalent in low technology companies manufacturing low-tech products or using low-tech processes.

The adoption of a Task Force approach is essential to the parallel development of a product and its manufacturing system. Computer integrated manufacturing techniques will facilitate product/process integration as systems develop. It is further observed that the adoption of new materials is often the catalyst for an integrated approach.

Q4 *How effective are the activities of Government departments in promoting and supporting innovation?*
Some criticism is levelled at the Department of Trade and Industry. DTI are perceived to have high visibility, but their current programmes are limited to small companies, involve excessive negotiations and subsequently require a high level of reporting. These problems are seen to result in projects that move too slowly, give little support for real innovation and few activities involving partnerships.

Government should help the spread of innovation in four major ways:

(a) Support for training.
  — Directly through grant schemes to enable expansion of training facilities for relevant courses, e.g., Manufacturing Systems Engineering.
  — Indirectly via building programmes for training institutes.
(b) Support for consultancy in innovative areas.
  — Current schemes are perceived to be too slow and too limited in extent.
(c) Dissemination of information.
  — Via journals, newsletters, videos, etc.
(d) Support for collaborative ventures.
  — Providing funding for secretariat of technology clubs, user groups, etc.

For small companies, the Business Growth Training Scheme is proving useful.

Q5 *What are the effects of City attitudes to investment in innovation?*
Strong condemnation of City pressure for short-term profitability is made by the Institution. The requirement for short-term profitability leaves companies with little scope for investment in innovation and inhibits the establishment of an "innovative culture".

Venture and development capital is stated to be limited and requires companies to focus on achieving high short-term returns whilst allowing the lender an easily defined exit route.

It is further perceived that the City's preference for acquisition, rather than longer-term organic growth, is damaging to both company and country in the long-term.

The status quo is expected to be preserved unless Government policy forces the City to take a longer-term view.

Q6 *What is the effect of the legislative and regulatory framework concerning for example labour costs, patent laws and tax concessions on R&D and the purchase of know-how?*
The Institution considers that labour costs, patent laws or tax concessions on the purchase of know-how have little relevance to good innovative programmes.

However, a key legislative issue is a requirement for companies to publish annual accounts against carefully defined guidelines. Additional information relevant to innovation would enable potential investors to assess more easily the long-term prospects of a business.

Taking an overview, it is considered that legislative recognition of a joint stock listed company should be more than just the physical book listed assets.

Q7 *How effective are the mechanisms for technology transfer from HEI's, Research Councils and public laboratories to manufacturing industry?*
There is general concensus that the present mechanisms for the transfer of technology from Higher Education Institutes (HEI's) is difficult. Often the best method of technology transfer is to transfer the people with the knowledge. The nation therefore needs to create a much more flexible arrangement between HEI's and industry, with more people with a foot in both camps.

It is appreciated that it is difficult for HEI's to actively market their technology: however, mechanisms must be found to achieve transfer. Industrial liaison units in HEI's may be an appropriate route, but it will be necessary to adequately fund them.

Traditional science or engineering research programmes are believed to be inappropriate for modern manufacturing needs. High quality PhD engineering programmes should be established.

The ACME and Teaching Company Schemes are beginning to work well with large and medium-sized companies, whilst the Regional Technical Centres are helping the smaller companies.

In summary, it is essential to interchange personnel between academia and industry and vice versa. Transfers should not be limited by remuneration differences or limitations by pension funds or conditions of employment.

Q8 *Does the UK benefit sufficiently from EC support for innovation? How might it be improved?*
The Institution sees only large UK companies engaging in pre-competitive collaboration with European companies. It is noted that such collaboration often works well and that the EC support was more significant than UK government assistance.

Most UK companies were unaware of EC schemes. Excessive EC bureaucracy deterred all but the largest companies from completing negotiations and participating in EC schemes.

Selected consultancies, which have a strong commitment to innovation, should be paid to work with manufacturing companies to identify suitable EC schemes, then commissioned to provide guidance to gain full EC support. The provision of more comprehensive databases on this subject would be beneficial.

The Institution believes that collaborative team-working in the UK needs to be better understood before industry can reap substantial rewards from EC programmes.

Q9 *What are the effects of the varying relationships between companies and their suppliers?*
The relationship between companies and their suppliers is a major area for improvement. Two critical issues of delivery and quality are identified as requiring special attention.

Adversarial attitudes to suppliers are too prevalent in many companies. Technical support for suppliers in areas such as Total Quality Management and CAD should be more readily available from customers. Companies should positively place resources at the disposal of suppliers to encourage innovative ideas and jointly assess the results.

Few companies have structured supplier development programmes for transferring manufacturing systems engineering approaches and which they support by good training programmes.

Q10 *What factors influence decisions to invest in innovation in the UK or overseas?*
The following key issues have been identified:

- Health of the economy.
- Availability of finance.
- Availability of engineers.
- Proximity to customers and markets.
- Operating costs.
- Return on investments.
- Availability of a professional supporting structure.
- Assurance that benefits will not pass to competitors.

The absence of a formal structure to deal with new ideas can lead to them being filtered out by short-term return on investment, rather than long-term market share.

Q11 *In the light of ACOST's report "Defence R&D: A National Resource", and the Government's response, is there a satisfactory relationship between the defence and civil sectors?*
The relationship between the defence and civil sectors is seen to be unsatisfactory in that:

(a) Companies that are not associated with a defence programme find it difficult to access defence technology;

(b) The Ministry of Defence often has a lack of understanding of the needs of a civil company.

The influence of defence standards on quality assurance is one example of the beneficial effects of defence technology.

OTHER POINTS

Over the last 10 years, there has been a very significant loss of major original equipment manufacturers from the UK. Many large companies have either reduced drastically in size or disappeared altogether, and the ownership of many others has moved to overseas companies. The innovation process is normally carried out close to the centres of power in any organisation. Thus, the amount of innovation being undertaken within the UK will have reduced.

Major companies need to be encouraged to stimulate their suppliers to innovate. The most fruitful source of ideas for innovation normally comes from customers. They are the people who have the needs. Sharply defined needs, coupled with demanding performance, cost and time targets, create the environment within which innovation is most likely to occur.

The fruits of innovation are only realised when projects are effectively managed. Project management in a complex multi-disciplinary environment, including both hardware and software development, is possibly the most crucial requirement for the next decade. It is one of the central skills possessed by members of the Institution of Production Engineers.

Memorandum by the Institutional Fund Managers' Association

1. The Institutional Fund Managers' Association has among its members a broad cross-section of UK-based fund management companies, including most of the leading names in the industry. Its 72 members have an aggregate total of funds under management in excess of £400 billion. As managers of pensions, insurance and other funds with long-term liabilities, our members are particularly interested in the United Kingdom's long-term growth prospects; sustained economic growth provides the best environment for optimising the return on the funds placed with them.

2. Our members are concerned at the credence being given to misinformed comment which seeks to place the blame for Britain's relatively poor economic performance on their supposed short-term attitudes to investment. They fear that an incorrect diagnosis of the causes of the problem could lead to the implementation of measures that are counterproductive and damaging to the economy and to the beneficiaries, policy holders and investors whom they serve. We have sponsored Professor Paul Marsh, Professor of Management and Finance at the London Business School, to make an independent study of the reasons for the United Kingdom's disappointing economic performance and hope to publish his paper early in November. We expect to be able to provide the Sub-committee with an advance copy of the paper towards the end of October. Meanwhile we would like to outline some of the most important issues.

3. The burden of the complaint against fund managers is that their supposed short-termist approach to investment leads to a mispricing of company securities, leaving well-managed companies vulnerable to hostile takeover. It is also alleged that, in an effort to boost their share price, companies will cut back on research and development. We believe that there is little evidence of a short-term bias in share prices; on the contrary, the overwhelming bulk of the evidence suggests that a company's long-term prospects are appropriately discounted in its share price. The evidence also suggests that financial markets react favourable to the announcement of corporate research and development programmes.

4. We believe that it is more likely that industry's disappointing record on investment is the result of poor economic prospects than the other way round. The United Kingdom's relatively poor economic performance reflects a complex of cultural and societal factors that have created supply side problems and obstruct the effective implementation of economic policy, and it is naive to attempt to pin the blame on any particular group. Admittedly, incorrect perceptions of City attitudes can lead to short-termist responses by industrialists, and we believe that there is a need for better communications between the two sides.

5. Most proposals to improve understanding between financial institutions and industry involve financial institutions exercising greater influence in company affairs. While we believe that there is much merit in this approach, there are limitations to the extent to which fund managers can intervene in the affairs of the companies in which they invest. Firstly, fund managers are not industrial managers; they are not qualified by training or experience to manage industrial companies and intervention in their day-to-day running would not only be resented by industrialists but be damaging. Secondly, fund managers' primary responsibility is to their clients and too great an involvement might prevent them operating effectively as fund managers.

6. The Association strongly supports the initiatives on corporate governance taken by various City institutions, including the Bank of England and the Institutional Shareholders Committee. We would also welcome greater disclosure by companies of their research and development programmes and believe that this would enhance their share rating and access to capital.

5 *October* 1990

Memorandum by the Japan—Europe Industry Research Centre, Imperial College of Science, Technology and Medicine

SUMMARY

(1) The points to be made reflect the Centre's research concerns—notably that of throwing light on British problems by explicit institutional comparisons with other countries, chiefly Japan. [A brief account of the JEIRC's nature and purpose is appended to this memorandum.]

(2) It has now come to be widely accepted that "short-termism" affects the capacity for innovation and that financial markets affect short-termism. It is therefore worth thinking through the consequences of adding, to the three existing objectives of financial market regulation, a fourth explicit priority—namely the promotion of R&D and long-term investment by manufacturing companies.

(3) If fear of takeovers feeds the concern with share prices that inhibits long-term investments, why not think of ways to curb takeovers? One might be a tax on the windfall gains from share price jumps as a share moves from the "market for income streams" to "the market for corporate control".

(4) High mobility of the labour force might be the blessing economists always say it is if allocative efficiency were all that mattered. But innovation may be favoured by long-duration employment. Reasons for this are numerous and include the benefits of fostering a "learning organisation" which is able to identify and profit from new possibilities. Implications for public policy are wide-ranging and affect employment protection and trade union legislation, and the legal regulation and tax treatment of pension funds.

(5) High labour mobility is often said to be good for technology diffusion. In fact it may inhibit it through defensive measures to ward off poaching.

(6) Technology diffusion is also inhibited by other factors, such as national and corporate habits of technological complacency (frequently egged on by political rhetoric), and by the lack of adequate institutional provision and encouragement to acquire and exploit existing overseas technology and to collaborate domestically in acquiring new technology.

(7) It is now widely recognised in this country that sub-contracting relationships based on mutual expectation of long duration can have a benign effect on the atmosphere for innovation. British firms fail to gain full advantage from attempts to move in this direction because of an unwillingness to recognise the necessarily hierarchical inequality of the power relationship involved. A clear-eyed recognition of this would have implications for public policy. For example, sub-contractors might be given some of the legal protection given to employees by employment protection legislation.

Introduction

We offer a few notes from the perspective of our own Centre's research. This is focused on the lessons to be derived from comparisons between Japanese and other countries' ways of organising industry. Such lessons are not simple "imitate Japan" prescriptions. The point of the comparisons is rather to understand better how things work; to know better what factors constrain what outcomes in order the better to define the limits of possible solutions to what are agreed to be problems.[1]

We hope the Sub-Committee will forgive us for taking its questions in an idiosyncratic order. We think it makes for a better exposition of our points.

Question 5—Even a year ago we would have wanted to respond at some length to the Sub-committee's question on City attitudes. We would have wanted to repeat what we have said elsewhere about the role of shareholders, and how it is that Japan encourages loyal-business-relationship shareholders as opposed to impersonal liquidity-preferring profit-maximising shareholders. Today, however, all this has become one of the cliches of the "short-termism" debate, recently given added stimulus by the report of the DTI's Innovation Advisory Board on city attitudes and practices. We would only make one point which is in response to one of the more interesting contributions to that debate—Barry Riley's article on pension funds in the Financial Times of 22 July 1990.

Riley argues that British captains of industry who complain about the willingness of institutional investors to sell them down the river for a takeover profit, and their unwillingness to back long-term investment, have only themselves to blame. As investors they behave in exactly the same way. "The problem is entirely self-inflicted. British companies have it in their power to tackle short-termism at its roots."

The point is well taken and we would quarrel only with the "entirely". The institutional framework surely also counts. At present that framework of law and custom is directed at/justified by three overt *public* policy objectives (i.e., excluding the hidden agendas of interested parties): investor protection, the promotion of competition in the interests of consumers, and the attraction of the maximum amount of the world's financial business to the City of London. There is a strong case for taking a new look at all these institutions with the following question in mind: what modifications would be indicated if these three were counterbalanced by a fourth objective; the promotion of R&D and long-term investment in manufacturing companies? Measures which might be contemplated include:

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[1] Some of the points made briefly in this note are spelled out in more detail in Ronald Dore, *Taking Japan Seriously*, Athlone Press 1988.

(i) Those designed to discourage rapid turnover of share portfolios and encourage investor loyalty: e.g., a graduated stamp duty varying according to the length of time shares are held; or a similarly varying capital gains tax such as is being contemplated in the US. Admittedly, these measures would probably have to be co-ordinated with the rest of Europe and perhaps with the United States in order to prevent market-makers and investors from taking their business elsewhere. This might not be impossible: the problem is not uniquely British, and awareness of it is spreading through all Japan's competitors.

(ii) As many others have pointed out, the counter-productive and long-term-investment-deterring effects of much takeover activity derive from the duality of the stock market.[1] On one hand it is a market in rights to income streams, on the other, a market in corporate control, and the value of any share is likely to jump significantly when it is perceived as being traded in the second rather than the first market. Might there be some merit in taxing the windfall value of such "jumps" (when they are brought about by an ultimately successful takeover offer) in a way analogous to the taxing of the development value of land in the old Town and Country Planning law? That is not a happy precedent, it might be thought, but Big Bang, computers and the immensely comprehensive recording system available in the City might make the administrative obstacles of a somewhat different order. The tax might be called a "goodwill tax" since as an accounting term "goodwill" has come to mean precisely the difference between the aggregate market-realisable value of a company's assets and what a purchaser chooses to pay for control.

Question 1. One does not need to go to Japan to find evidence for the following proposition: firms whose employees expect both to be allowed to stay, and to want to stay, with their firms for a very long time, if not for the rest of their working lives, are more likely to be successful innovators than firms with a constant turnover of personnel. This is true of small firms, as some of those from which the Committee has taken evidence illustrate, as well as large ones, but we think it is a particularly important point in the case of large firms, which do most of the R&D in the UK and contribute more to employment and export earnings, (and which have in many cases been withering away over the years at the expense of large foreign competitors). Casual empirical confirmation is provided by firms like IBM, Hewlett Packard, ICI, Unilever. And the likely reasons for the correlation are not hard to imagine:

(i) People who are not constantly looking at the job advertisements in the Sunday papers, and wondering where to move next, have more time and attention to give to their present work;

(ii) They have a long-term stake in the firm's future, are therefore more likely to be concerned about developing new products for a long-term future than about getting more milk out of an ageing cash cow

(iii) More willing, therefore, to moderate their salary and wage expectations when the firm is going through lean times of reconstruction for a better long-term future; less likely too, to insist on executive compensation schemes linked to short-term departmental results;

(iv) If they have been around for a long time, they are more likely to know personally the people in other departments: hence the co-operation which all innovation requires and product innovation especially—between design, production, sales, finance—may be more easily obtained.

(v) If they are not expecting (and therefore not expected) to change jobs every couple of years, it is much more in the firm's interest to ensure that all of them, from management and senior researchers to technicians and shop floor workers, get as much training as may benefit them and equip them to do their jobs better. Some of this training at least is going to make them better able to devise improvements or adapt to changes of other people's devising.

(vi) If employees have good reason to fear that the commercially successful introduction of technical or other innovation is liable to lead to job losses, they have every reason to develop an instinctive suspicion of, and even active resistance to, all forms of innovation, thereby creating a culture of inertia and "quiet-lifemanship", to which firms whose employees have survived a long period of continuing change and expect to stay longer are less likely to fall prey.

The Committee's initial response may be: All right. We accept that. And the "lifetime commitment" may well be one of the secrets of Japan's success in rapid innovation. But so what? What can public policy do about it? Loyalty commitments are an aspect of culture. You either have it or you don't.

That, again, would be to ignore the importance of institutional arrangements. In Japan in 1920, employment durations were much the same as in Britain; lifetime employment was largely confined to the civil service, the police, etc., and in the private sector, as in England, to the banks, the major trading companies and the railways; and within them largely to white collar workers. It spread from the blue chip large corporations downwards for a variety of reasons; trade union concern with job security and with what we call in Britain today "harmonisation"—equalisation of conditions for blue and white collar workers (not so much, perhaps, because Japan is a country where the pressures for single-status conditions were or are stronger than in Britain, as because the forces resisting their introduction remain stronger here than they were there); the growth of milk-round type recruiting (from a meritocratic hierarchy of government-run schools), and the laws governing pension arrangements.

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[1] A point well argued in a paper by Andy Cosh, Alan Hughes and Ajhit Singh for an Institute of Public Policy Research conference (to be published October 1990).

There is the potential for similar trends in Britain, but whether those trends gather force or not will be influenced by the legal and institutional environment. It *is* a matter for public policy.

In Britain at present, it is generally assumed that economic efficiency requires an active labour market with human resources constantly being reallocated between firms so that they are always put to their most efficient use. Sluggish labour markets with low mobility between firms are considered part of the "rigidity" of stagflation.

It is hard to think of a dafter application of the principles of neo-classical economics, which assume the relation between a factor of production and its output to be a matter of fixed coefficients. Human skill-packages can, it is claimed, be slotted into any niche which provides the appropriate capital equipment and produce everywhere the same results. That may be so on a cotton plantation, but not in the sort of sophisticated systems which modern manufacturing increasingly requires. As the author of a chapter on automobile industry sub-contracting puts it in *The Japanese Enterprise*—a recent Japanese book which we are translating[1]:

> It may be difficult for those familiar with neoclassical equilibrium analysis to fully appreciate the importance of the mutual transfer, mutual communication, of the finely tuned skills and know-how accumulated by each economic actor within enterprises.

and he goes on to stress that organisational learning—the systematic methods of ensuring the steady lowering of costs and the improvement of quality—are highly dependent on stable personal networks. The so-called "learning curve" is sometimes spoken of as if it were an invariate law of nature that each doubling of cumulative output reduces costs by 20 per cent. Nothing of the kind, as a careful recent survey of the literature shows.[2] There is immense variation between organisations in the speed and extent of learning gains. Some organisations are effective learning organisations, and some not, and the stability of the networks in which the learning has collectively and co-operatively to be done is judged by the authors to be a major determining factor.

If the proposition that stable employment enhances innovation efficiency be accepted, the implications for public policy ramify through employment protection legislation and trade union legislation to the legal regulation and tax treatment of pension funds. Maximising the capacity of British industry to innovate is, of course, not the only object of policy. There may be trade-offs with the maximisation of personal freedom of choice. But at least, if one takes the view that encouraging long-term employment, rather than encouraging maximum mobility is desirable from an innovation-efficiency point of view, one looks at these issues in a new way.

For example, recent attempts to make pensions portable are in line with the "active labour market" objective and are thought to promote economic efficiency as well as personal freedom of choice. If one wants to encourage long employment durations they are counter-productive. This is, indeed, the conclusion reached by Lester Thurow, the dean of the Sloan School at MIT and an influential member of the MIT group which wrote *Made in America.*

It has to be said, however, that the adoption of features of the Japanese employment system like the career employment guarantee may not necessarily produce the attitudes to towards, and capacity for, innovation characteristic of the Japanese firm—if, that is the adoption of those features is a matter of piecemeal tinkering rather than that of a coherent attempt to shift towards some conception of the firm as a work community. That, at least, was the conclusion of a study of firms in the British pump industry conducted by our Centre. A summary of the findings of that report is to be found in Appendix 4.

Question 2 The question of "seeking out external technology" relates directly to the long-term employment issue. It is often argued that an active labour market, particularly among skilled workers and technologists, is a crucial mechanism for the diffusion of technology. The speed with which technology diffuses to and within Japan would seem to suggest that it is certainly not a *sine qua non.*

A recent issue of *Technology Strategies* (July 1990) summarises a National Science Foundation Study which compared the research styles of university, corporate and government laboratory researchers in the US and Japan. They found that 85 per cent of Japanese researchers attended technical meetings outside their work location at least twice per month, whereas only 30 per cent of the Americans did the same. In Japan, 83 per cent of researchers said they were aware of recent research advances made in their field by foreigners. The American percentage was again 30 per cent. Of the Japanese, 65 per cent had spent a year in the US. Only 34 per cent of the Americans had ever had a year abroad anywhere.

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[1] Miwa Yoshiro, "Shita-uke-kankei: Jidosha sangyo", in Imai Kenichi and Komiya Ryutaro, *Nihon no Kigyo*, Tokyo, Tokyo Daigaku Shuppan, 1990, p. 165.

[2] Linda Argote and Dennis Epple, "Learning curves in manufacturing" *Science, 247,* 920-924, 23 Feb 1990.

One suspects that the Not Invented Here syndrome might be even stronger in Britain than the US.

In Japan's case (less so for Britian, so close to the rest of Europe) diffusion of technology to Japan and diffusion within Japan need to be treated as separate issues. The efficiency of diffusion *to* Japan is clearly influenced by the fact that for four generations Japan has been overtly defined by its citizens as a catch-up country needing to learn all it can from the West. Even now, when they are leaders rather than followers in a number of fields, established habits and established mechanisms for seeking out knowledge overseas have their own inertia. Particularly important are:

- The tradition of sending young researchers overseas—from corporate and government laboratories as well as from universities—for an extended period at an early stage of their career. (Note the 65 per cent figure just quoted.) Personal networks thus created continue to act as information channels.
- The trading companies, which maintain small technology divisions in major countries to do technology reconnaissance for their client firms in Japan.
- "Listening post" offices in foreign countries maintained by companies which may be doing little commercial business in those countries but which wish to be kept informed of significant technical developments.
- Increasingly, nowadays, research and development centres overseas which recruit talented locals (Americans, British, Germans, and others) and harness their mental resources for the benefit of the corporation; this is not only a good way of getting work done which is relevant to local market conditions, it also provides the home company's researchers with a line of direct communication to what is going on in the overseas research community.
- Publicly supported data bases.
- Organisations which enjoy the support, encouragement and where appropriate participation of government and industry which have as defined functions the gathering and dissemination of useful knowlege, including technology: examples range from the MITI agency JETRO (conceived on the model of the now-defunct British External Trade Relations Organisation), and the Metal Mining Association of Japan, to the Japan Management Association (JMA) which over the past 20 years has organised numerous regular overseas study missions for research managers from assorted major companies.

It is hard to think of possible British surrogates for the trading company role, (unless it be a strengthening of the scientific attache staff attached to embassies), but the other items raise questions:

- Does SERC put enough money into overseas exchange arrangements for young British scientists and technologists? Japanese companies, relying on their young researchers returning to the firm after a year or two of study overseas, are able to act with the confidence that in the UK is (still) the preserve of the Civil Service; since British firms are too nervous to imitate them, should there be more provision to encourage and enable science and engineering PhD students to spend time overseas *before* they complete their studies and enter the job market?
- Should more not also be done to strengthen the Visiting Engineers Scheme (and Engineering Secondments Overseas, a similar but broader programme which is also administered by the Fellowship of Engineering)? These schemes, like the slightly larger European Communities Scientific Training Programme in Japan, provide opportunities for young engineers to gain experience of working in their area of expertise with Japanese counterparts and in Japanese organisations, but are comparatively little known and ineffectively publicised. Usually little effort is made to equip the participants to benefit maximally from the experience (surprisingly, there is in the case of the British schemes no prescribed provision for reasonable language training before departure nor indeed after arrival). Similarly, their employers rarely make much attempt to exploit the experience they have had and the contacts they have made; nor is there any kind of national network to link them together and put their experiences collectively at the disposal of others. It appears that similar criticisms could with justice be made of a number of similar schemes.
- Is the DTI's OSTEMS (Overseas Science and Technology Expert Mission Scheme) as effective as it could be? The Scheme is a sensible attempt to supplement the British stock of technology transfer mechanisms. But knowledge of the scheme itself is inadequately diffused; and although the DTI instructs missions to present their findings in the form of a report, to be made available at or below the cost of reproduction and distribution, some missions charge £50-£65 or even more for their reports, others no longer keep copies, and in some cases the sponsoring organisations are believed even by some DTI officials to have ceased to exist, leaving no lasting trace of the fruits of their missions (surprisingly, the DTI does not itself retain a complete set of mission reports); all this helps to ensure that the benefits of this imaginative and well-funded scheme are not as widely distributed as they should be.
- Should the offices of the Science and Technology Counsellors in British Embassies overseas not be strengthened, as suggested by the Fellowship of Engineering (Evidence p. 65)? Perhaps even more worthwhile might be, first, to do more to diffuse knowledge of the valuable work they do: for example, by giving better publicity to the Overseas Technical Information Service (OTIS) and its affiliated online database access service (OTISLINE), which offer astonishingly good value for money but are surprisingly little known. The present tendency seems to be in the opposite

direction, since information provided by Embassies abroad is said to be increasingly being made available only if paid for, an effective means to limit diffusion through industry and the academic world.

- So far as we are aware, only two British companies have yet established R&D centres in Japan; this at a time when the proportion of patents by Japanese companies cited in US patent applications, and the proportion of articles by Japanese quoted in science and engineering research journals, are both steadily rising. US companies, much more conscious of the need to measure themselves against Japanese competitors in an ever-growing range of increasingly technology-dependent industries, have decided on setting up at least five R&D or technical centres in Japan in the past eighteen months alone. Perhaps, in view of the slowness and timidity which characterise the British approach, and the high cost of getting such centres started, the Government should offer assistance or encouragement to firms or possibly to consortia of two or more companies which plan to set up joint facilities?
- Is the British Library's Science Reference and Information Service—and in particular its excellent Japanese Information Service in Science, Technology and Commerce—sufficiently well-endowed, and are enough efforts made to make firms aware of the services it can offer and the use that can be made of them? (Probably not, since the very future of the Japanese Information Service is currently said to be in doubt). Are the professional patent-gleaners on which may firms rely adequate to their task?

International search channels can clearly be improved, but the more important point to stress, perhaps, is "diffusion within". The 85:30 per cent contrast between Japan and the US (in the findings of the survey quoted above, regarding the frequency of attendance at technical meetings outside the workplace) is striking. Part of it must be deep-culture; Japan just is a more learning-oriented country which believes the University of London's motto: "Knowledge is Power" even more implicitly than those earnest Victorians who adopted it.

But part of it is cultural in the shallower sense in which one talks of the "culture of the firm". The Japanese, despite the intense rivalry between firms in their domestic markets, seem not to be much worried that their researchers are going to give precious ideas and discoveries to their rivals. The British obsession with commercial secrets derives from a view of innovation cognate with the neo-classical view of labour markets pilloried above. Steal a crucial piece of information from a competitor, feed it into your organisation and out comes the profit. The Japanese are more likely to see the sort of ideas picked up at conferences as taking you only 10 per cent of the way towards a successful innovation; not so very important compared with all the research, evaluation, design, development, production and marketing work (and frequently substantial investment in plant) that has to follow.

It is partly ideological: there is less concern in the more pragmatic climate of Japan to ensure that benevolent intervention by government is "market-led", (although there is a wide recognition that this is a notional ideal to which it is good to claim to aspire, particularly in discussion with foreigners). For example, in the UK not only OSTEMS, but other missions and exchanges with Japan (and no doubt elsewhere), are liable to be run on quite tough commercial principles even if largely paid for out of government money. Information may be made available, conferences are held (though not always successfully publicised), but at a commercial rate. This helps not only to impede wider distribution of useful knowledge, but to discourage some of the kinds of fruitful contact and exchange of views and experience which a more open and openly activist approach can stimulate.

It is also partly institutional. Lifetime employment breeds trust. Many British firms know that if they send their best and brightest researchers to conferences, they are almost bound to get job offers, and that they might be tempted by one of them. And they know that the professional ethic—you can buy a man, but you don't get the commercial secrets of his firm as part of the deal—is weak indeed. Japanese firms do not have that worry—or, at least not to the extent that it outweighs the benefits of regular contacts between their researchers and colleagues elsewhere. Another reason why the encouragement of long-term career employment has much to be said for it.

Question 9 Here is another question on which the preaching we would have been inclined to do some years ago would now probably be wasted on the converted. Or at least on the in-principle-converted. There is a great deal of talk at conferences and in business schools about the need for large firms to "nurture the supply chain", build up long-term relationships, develop the trust relationships which enable innovation to be a joint supplier-buyer partnership. And there is a general recognition that the propensity to do just that is a source of Japan's manufacturing strength. But practice lags well behind, as is demonstrated in a recent London PhD which makes a detailed comparison of subcontracting in the electronics industry in Britain and Japan.[1] And the recent survey by the Japan External Trade Relations Organisation[2] showing that 70 per cent of Japanese manufacturers in Europe are dissatisfied with their sub-contractors here suggests that something is seriously wrong (and that British suppliers in more and more industries are increasingly likely to face stiffening competition from firms which are beginning to come here from Japan in the wake of their large Japanese customers).

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[1] [5]Mari Sako, London Phd thesis 1990. The thesis is based on research supported by an ESRC grant, partly at JEIRC.

[2] [6]*Current Situation of Business Operations of Japanese-manufacturing Enterprises in Europe, The 6th Survey Report*, JETRO, International Economic and Trade Information Centre, Narch 1990.

This is a field where the lesson is generally interpreted as a straightforward "imitate Japan" one. The trouble in Britain seems to be that the imitation is half-hearted. Managers talk about nurturing the supply chain *without* abandoning the principle that the smart business man should never be deterred by extraneous considerations from seizing whatever is, at any one moment, the best bargain in terms of price and quality (but above all, price). It is not generally appreciated that the efficiency characteristics of the Japanese system depend on two important features:

1. The supplier relationship in Japan depends on an implicit, but well understood, reciprocal bargain. The supplier is to make *every effort within reason* to maintain quality and reduce prices, to co-operate in new product development, to keep its buyers' commercial secrets when given advance notice of new models. The buyer, likewise, *as long as the supplier is making the expected efforts* (and even if for reasons unconnected with that effort he ceases to be price-competitive), is to make every effort within reason to give continuity of orders to the supplier, to give advance notice of product changes, to provide uncosted technical assistance, etc.

2. But, in contrast to the British fiction that all inter-firm contracts in the market place are contracts between equals, the *hierarchical* nature of the relationship is well understood and accepted. The fact that (except for a minority of high-tech firms with some kind of technological monopoly) suppliers have less market power and resources than buyers, than the parts supplier is more dependent on the automobile firm than *vice versa,* is accepted as a fact of life. Among the consequences of this acceptance of the fact of hierarchy are:

   (a) The buyer is the judge of whether the supplier *is* making every effort to give good service, and whether, therefore, the buyer is under an obligation to continue giving orders. It is accepted, in other words, that the power relationship puts sanctions in the hands of the buyer much stronger than those in the hands of the supplier. But the "reputation effect"—the ethic of "restraint in the exercise of power by the stronger"—is sufficiently pervasive that buyers are constrained by a general conception of fairness. As Miwa puts it in the article quoted earlier:

   > If an assembler [he is talking about the motor industry] wants to suspend or reduce its transactions with a sub-contractor, it must assess whether its action will be seen as justified by all of the firms with which it conducts transactions.

   (b) That, nevertheless, buyers are sometimes unscrupulous in the exploitation of their superior market power is recognised in Japan as a problem of public policy. There is a wide range of sub-contractor protection legislation on the same lines as our employment protection legislation. There are summary tribunals, like our labour tribunals, to deal with sub-contractors' complaints. There used to be occasional government campaigns to make sure that sub-contractor relations are backed by written documents which spell out the norms governing the relationship in ways of which a court will take cognisance. "Used to be" because the frequency with which sub-contractors bring cases to the courts has diminished. The laws are now of only marginal importance—but that is a sign that they have done their part in *institutionalising* the norms of fairness which regulate the relationship.

The Sub-Committee might like to consider whether it could be a helpful step in improving the efficiency of inter-firm transactions if we too treated the sub-contracting relationship as on a par with the employment relationship as deserving of protective measures for the weaker party. Or whether the British addiction to notions of market egalitarianism are too strong for that to be contemplated.

More generally, it might be worth considering the various measures which have been taken in Japan to embody the general perception that small- and medium-sized enterprises are both (a) inevitably underdogs liable to be downtrodden or at least disadvantaged in their relations with larger firms (notably but not exclusively monopsonistic customers), and therefore need and deserve special help and protection; and (b) a major national resource which must be carefully tended and encouraged to fulfil its potential in contributing to the nation's economic and technical progress. If the standpoint of the Japanese model seems too remote and exotic from a British perspective, the very successful measures taken by the German government in recent years to stimulate research and development activity by small-to-medium-sized firms (i.e., those with under 500 employees) would probably be equally illuminating.

Question 4. Perhaps we might comment on two aspects of the evidence from the Fellowship of Engineering on the reasons why, as they put it, "other countries, principally Japan through MITI, have been much more successful than Britain" (Evidence p. 63).

They concern:

1. The alleged remote ineffectiveness of senior staff in the British civil service.
2. The "National Plan" alleged to be a key factor in Japan in ensuring the effectiveness of government intervention.

1. Japanese MITI bureaucrats are even less likely to have had careers in industry. The probability is close to zero. But they are not remote because their jobs require them to be constantly in contact with people in industry. Co-operative research projects are never born full-formed from a civil servant brain. They are worked out in close conjunction with firms. The existence of strong industry associations helps in this. (In the UK, too, when the old Product and Process Development Scheme required DTI officials to be constantly visiting factories, many acquired an expertise which a lot of firms found helpful for their own planning of product development processes, as a Technical Change Centre study showed.)

2. The National Plan. The periodic MITI "visions" which distil the industry consensus about what technologies are going to be important over the medium-to-long term do affect R&D management decisions, but it is absurd to call them a plan. The crucial government role, as suggested in the last point, is to provide, *with* industry associations, fora for discussions and frameworks for co-operation between firms, and among firms, government laboratories and universities. The "Little Neddies" sometimes perform that function here. A study of what ingredients make for a successful "Little Neddy" and what are the explanations for their failing to make their mark could be useful. Of course, the various government-sponsored technology projects, frequently involving *ad hoc* engineering research associations, are liable to be seen by some foreign observers as components in a plan. Such projects, for example the Next Generation Base Technologies Programme, the Large Scale Project series, the "Sunshine" and "Moonlight" projects and others co-ordinated by MITI, fall far short of being elements of a National Plan. They do however help to concentrate the minds of a lot of people in major companies and in MITI and its affiliated national research laboratories, and to a limited extent in universities, on the directions in which commercially important technology is heading. This should not obscure the facts that (a) the government's financial support for these programmes is trivial by comparison with the overall R&D budgets of the larger firms; (b) the projects bear witness to the willingness of large companies to accept an interventionist, or at least activist, role by government which might be considered controversial in the UK; and (c) research collaboration is not confined to those cases where firms are arm-twisted into it by MITI, and conversely plenty of firms are able to stay out of research associations despite pressure to join (for example if they think they have nothing much to learn and are liable to end up helping their weaker rivals).

RONALD DORE
DAVID CAIRNCROSS
November 1990

APPENDIX 1

The Sub-Committee did not specifically invite evidence on the education system, on the factors which constrain vocational training in and out of employment, or on the inhibiting effects on innovation of the peculiar structure of the British engineering profession. We are therefore reluctant to discuss these at any length, although we consider them very relevant to the subject at issue. We confine ourselves to noting some features in which the Japanese scene differs from the UK, some of which may not be widely appreciated here as yet:

Japanese school education after 15 is not compulsory, and indeed is fee-paying even for state schools, although fees are admittedly modest except in the case of the minority of private schools. Nonetheless 95 per cent of 15-year-olds progress into senior high school and 90 per cent remain there for the three years to graduation. Admission to senior high schools—including state schools—is generally selective. It is consequently not true as it is in Britain that the overwhelming majority of academically outstanding schools are private.

On the other hand the selective spectrum runs down an extended and quite finely graded hierarchy, and about one-third of pupils are in vocationally oriented streams or schools (which however embody a very substantial academic component and often have a high reputation): consequently the system is quite unlike the old grammar/secondary modern divide which split the 11-year-old population simplistically into a handful of sheep and an army of undifferentiated and often hopeless goats. Schools at all levels, both private and public, compete within their catchment area on easily-verified (and self-fulfilling) reputation for academic merit. All high schools (and universities) at all levels of age and academic status have entrance and graduation ceremonies (and school songs), which means among other things that the entire post-war generation shares the egalitarian and dignifying experience of graduating from junior high school, and almost all young people now share that of graduating from senior high school too.

According to a 1983 report by a British Council official (broadly critical of the quality of Japanese maths education), about 90 per cent of Japanese pupils do some basic differential and integral calculus before they leave school; this is contrasted with 15 per cent in the UK, but this figure is open to question and it should be noted in any case that proposals have been made recently to drop calculus altogether from maths A level and that fewer than 2 per cent of the relevant age group take maths A level at present. We understand that a similarly striking contrast would appear if we substituted complex numbers for calculus. A knowledge of calculus and complex numbers may not be an essential piece of intellectual luggage for most people, and much of what is learned at school is soon forgotten, as the Sub-Committee will be aware, but—for example —a country in which everybody has been exposed to quadratic equations before the age of 16 has a good chance of conceiving and implementing industrial innovations more effectively than one where maths at this level is widely thought to be a difficult and abstruse subject.

Employers are keenly interested in the academic status of new recruits, including those hired to do blue-collar jobs. Academic achievement is measured primarily by the kind of school one was able to enter rather than, for example, performance in GCSE-style public exams, which do not exist. Since there is a hierarchy of preference for different employers (by school leavers and college graduates, who tend to prefer large firms over small ones, partly because the former pay more), it follows that this order is exactly reflected in the educational hierarchy of new recruits, in other words the best school leavers get to join the most desirable firms, and so on. Employers cultivate good relations with selected schools in order to improve their chances of persuading teachers to encourage good recruits to come to them. They do not seek to influence the syllabus, which is quite narrowly academic, and in any case strictly controlled by the Ministry of Education.

Similar principles apply to universities, which absorb 35 per cent of all 18-year-olds. The universities, being less numerous than senior high school, are ranked in hierarchical order of academic merit (or difficulty of entry) than senior high schools. There are many other kinds of further education and training establishment for post-18-year-olds, but there is no distinction comparable to the mysterious British contrast of "universities" and "polytechnics".

Pay in Japanese companies continues to be closely linked to seniority. Wages for 15- 17-year-olds are 71 per cent of the average wage of 20- 24-year-olds and 45 per cent of the average for workers at all ages. These percentages are not much more for 18- 19-year-olds (51 per cent and 82 per cent respectively). Time spent training them represents a relatively small investment, whereas failure to train them adequately will become increasingly expensive as they get older. Employees do not have rigid job definitions which define their level of skill and the domains in which it may be exercised, and when a union exists it embraces all employees of a firm and makes no distinction between different skills. Differences in *rank* do exist, along a finely graded hierarchy up which some progress is certain for all long-term employees, depending on a mixture of seniority and merit. The system is rather like the armed forces in this country. All employees are "members of the company". It is in the interest of the company that these members have the maximum possible range and level of skills of all kinds which they may be called on to use.

The Sub-committee might like to consider the suggestion that there are some parallels between, on the one hand, the British/Japanese contrast in education and training of industrial workers generally and on the other the training and employment of engineers. British skilled workers tend to divide themselves into different trades with mutually exclusive competences, responsibilities and trade unions, thereby narrowing their approach to their work, their potential for broadening and deepening their range of skills, and their overall usefulness to their employers, particularly in times of rapid technical change. Similarly, British graduate engineers insist on dividing themselves into a rich variety of species each of which has its own Institution which has been granted authority to decide who is, for example, a mechanical engineer and who is not. Attempts to create a more substantial over-arching framework which might effectively bring all professional engineers under one roof and give some sort of collective oomph to British engineering itself have been repeatedly frustrated, partly thanks to the parochial concerns and horizons of the leaders of the engineering profession.

Similarly the caste distinctions embodied in the difference betweeen polytechnics and universities are reflected in the failure of attempts to create (or upgrade) technical institutions which could provide a recognised and desirable graduate-level education and training in engineering subjects alone. The fundamental principle is the determination to ensure that status can be preserved by using titles with cachet rather than by demonstrated excellence. Arguably this is an inevitable consequence of giving the same institution which represents the interests of the practitioners of a trade or profession the power to decide who else may practise it. In Japan, such power is far more likely to depend on the consumer of the practioners' services, i.e., the employer.

APPENDIX 2

NOTE ON THE JEIRC

The Japan-Europe Industry Research Centre was set up in 1986 as an independent unit within Imperial College of Science, Technology and Medicine. Its main objectives are to conduct, stimulate and foster: internationally comparative **research** with a bearing on industrial policy, science and technology issues, education and training, and other topics which have an impact on competitiveness; **liaison** between Imperial College and the world of Japanese science and technology; and **training** for young British or other graduates to work as researchers, scientists, technologists or businessmen in a Japanese environment.

APPENDIX 3

To get some idea of the background, and continuity, to Japanese attitudes and institutional structures for promoting technology in the national interest, it is worth quoting at length some extracts from a report on reconstruction produced in 1946 by a group of concerned, and subsequently influential, citizens (most of them academics) who had begun their deliberations in secret before the war's end[1]

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[1] *Basic Problems for the Postwar Reconstruction of Japanese Economy*, Translation of a report of the Ministry of Foreign Affairs Special Survey Committee, September 1946, pub. Japan Economic Research Centre, Tokyo, 1977.

This report was by no means clairvoyant in its predictions, as examples like the following show:

> "Since the nation is [also] expected always to suffer a deficit in its trade with the rest of the world in the future, it will need to sustain a domestic gold production".[1]

However, it can be said to have been far-sighted in its analysis of the problem and recommendations, and on the aspects of foreign models which had merit:

> ". . . The establishment of a large number of laboratories and daring spendings on research are requested in order to encourage technological research. Thought has to be given to the point that a single brilliant invention may bring about an economisation or the creation of national wealth in amount of scores of million yen; and that an encouragement of technological research is the most basic means of cultivating productive capacity." . . . It may be appropriate . . . "to set up a research association by joint contributions of the firms in one product line, *to which a subsidy of a considerable amount may be given by the government as is seen in the example of the United Kingdom*. Spendings on research should be made every year uninterruptedly.[2] Government appropriations in the past were so unstable that inconveniences were caused in the execution of research which extended over a long period. It may be a good idea, therefore, to adopt the method that an independent organ such as a research foundation be established; that the government contributes funds to it every year in an amount appropriate for its financial ability in the year; and that donations by private organisations or individuals to this foundation be encouraged, for example, with tax credit. For an efficient use of research funds there will be the need of, so to speak, the 'research managers' in a good sense, who have a comparatively wide range of views and understanding of research, making their advent, because able researchers are not necessarily able accountants, and also because it is a national loss that researchers will have to spend much of their time in economic or other miscellaneous affairs. For an effective allocation of research funds, a democratic method should be contrived to ensure that funds may be granted plentifully to those who have actual capacity by publicising the research results and subjecting them to active criticism and analyses.
>
> "In Japan the division into various disciplines which was set up only for the convenience of research and education are kept with jealous care. As a result there exists a jealous sectionalism among various technological branches . . . Such phenomena would delay progress in the intermediate fields which exist in various engineering branches, for example chemical machines and electrical materials . . . So that such abuses may be corrected, there are the needs to elevate the common sense of engineers, and to have them form the habits to take a wide view of matters and to proceed straightly toward the solution of any issues without being prejudiced by their specialties.
>
> "The United Kingdom is apparently making efforts, government and private together, to recover the past hegemony of its goods in the world market; encouraging all kinds of technical research; and in particular, making a thoroughgoing examination of the defects of its goods in the past in an effort to reconstruct its economy which was devastated by the last war. Japan also has to proceed steadily with preparations from now in order to secure a worldwide reputation of its products; by conducting as soon as possible a thoroughgoing and systematic research on all aspects, including materials, plans work, processing methods, designs, etc., with respect to the production of the commodities which will become principal export items in the future . . . and also by reinforcing the system for inspecting export commodities and guaranteeing their quality."

APPENDIX 4

Pulling together: New industrial relations patterns in British engineering.[3]

SUMMARY

The underlying research question was relatively simple: There is much talk in the management literature, if often not very analytical talk, about "involvement". There is equally a great deal of talk about the need for more rapid and efficient innovation in industry. Is there any empirical evidence that an increase in the "involvement" of workers increases the capacity for innovation?

The research concentrated on a single industry, the pump industry, and involved an extensive survey of twenty-seven firms and an intensive institutional study of six.

There were two basic approaches to the research question. First, indices of both "involvement" and "innovativeness" were devised; measures for the 27 firms were made, and a correlation between the scores sought.

The setting of an operational definition of "involvement" started from the assumption that the employment systems of Japanese firms—incremental scale, person-related rather than job-related or piecework-based wages; plant bargaining and wage structures; works councils, quality circles or

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[1] *Note:* Although the premise has been subsequently falsified, gold continues to be mined in Japan with active government support.

[2] *Note:* All emphases added.

[3] R Dore, M Dodgson and H Whittaker, JEIRC Occasional Paper, 1988,

departmental discussion groups; highly developed internal training systems—represented an extreme pole of high involvement. Firms were measured on the extent to which they approached that pattern—as opposed to the most "commodified labour" pattern: piecework wages; hire and fire; external bargaining "in the market"; do-as-you're-told work assignments. Firms were rated on where they stood between these two poles.

Innovation was measured by a variety of characteristics of the firms's structure and its performance (in introducing new products and processes, for example) over recent years.

No whiff of a correlation between these two measures was discerned.

In the six firm sample, there was much more detailed analysis of pay systems, supervisory systems, formal and informal bargaining systems, and of changes in those over the first half of the eighties. Considerable movement was, in fact, discerned.

This was matched, in the same firms, by "event analysis"—the circumstances surrounding one piece of widespread innovation, namely, the introduction of CNC machines. Again, no clear correlation emerged between the position of firms on the "involvement/commodified labor" spectrum, and the smoothness of introduction of the new machines.

We came to this conclusion: Most of the movement along the "involvement" spectrum had been ostensibly rationalised as the pursuit, both of "involvement" and of "flexibility," the assumption often being that the two were intimately interrelated. In practice, very few of the many changes in personnel systems we examined were inspired by any notion of seeking to achieve a state of "high involvement". Most were tinkerings which achieved limited and specific flexibilities through the offer of equally specific material incentives, thereby leaving the basic "commodified labor" pattern of the employment system intact, and doing little to alter patterns of motivation.

APPENDIX 5

Letter to the Editor, Financial Times, published on 9 November 1990.

Dear Sir,

Unless he has better arguments than the writer of your leading article (7 November), Paul Marsh should not be allowed to get away with the notion that capital markets should be absolved of the charge of fomenting short-termism. It is not only, as your leader suggests, fear of takeovers which keeps managers nervously watching their share price, anxious always to feed it with a good earnings record now and not in five years' time. There are at least four other ways besides the absence of takeovers in which the structure of capital markets pushes the Japanese industrialist into short-term considerations less than his British counterpart:

1. The predominance, among his shareholders of locked-in friends, his bankers, his insurers, his suppliers, his distributors, firms with which he shares joint-venture subsidiaries, etc.
2. The small weight, among the other shareholders, of funds managed by frenetic index-beaters—especially the unit trusts which, as the Wilson Committee showed, turn over their portfolios a good deal more tempestuously than other categories.
3. The fact that no-one pretends the stock market is an honest place. Rigging is rife, known to be rife and accepted as part of the natural order of things because people still have the quaint belief that the making of things and the providing of services is somehow more worthy than making money through speculation, however computer-programmed the crystal-ball "system" they use. Hence managers do not see fluctuations in their share prices as reflecting the judgment of "their best informed peers". They are not touched in their egos.
4. The debt alternative to equity is provided by well-informed bankers who are also in business for the long-term because *their* shareholders are like the industrialist's.

Capital markets are not the source of *all* the institutional determinants of short-termism, of course; executive compensation schemes and high rates of managerial job mobility have a lot to do with it too. But complacent absolution of our City institutions is not helpful either.

RONALD DORE

Memorandum by KPMG Peat Marwick McLintock

MAJOR ISSUES RAISED IN THIS PAPER

In this paper we aim to demonstrate that:

- Manufacturing is very important to the UK economy.
- Competitive pressures have increased dramatically in the past decade and to remain competitive we now need to make quantum changes.

- Companies need a structured framework to successfully manage strategic level innovation.
- There is a wide scope for innovation in both products and processes.
- There are many road-blocks and barriers that can easily stifle or kill off the innovative spirit.
- In order to release the full potential benefit from "innovation" cultural change is necessary with special emphasis on the potential of people, and
- The way we measure performance needs to be re-shaped to become more relevant to todays' manufacturing environment.

MANUFACTURING MATTERS IN THE UK

Manufacturing is the central value adding activity in any industrialised economy, including our own. Manufacturing currently provides about 25 per cent of our Gross Domestic Product and employs nearly one in four people. It delivers about 80 per cent of our visible exports and accounts for about 40 per cent of our current account credits. It can be seen therefore that manufacturing is very important to the UK. For every job lost in manufacturing, the service sector has to create three new jobs to generate the same added value. In all 10 million jobs,—that is 38 per cent of the workforce, are wholly dependant on manufacturing.

THE STRATEGIC CONTEXT

We see shorter product and process life-cycles—so we have less chance to cashin on mature products. Innovation lead times are shorter and a manufacturing organisation will experience great difficulty if it cannot bring products to market ahead of the opposition.

We can no longer just be producers and we must recognise that in many industries there has been a shift in the value added from our production operations to product design and the total supply chain.

There is ever more potential for differentiation from increased information intensity and the application of information technology. There is also a growing recognition that if we put a strong emphasis on the potential of people in manufacturing despite all this change we can win orders through an unswerving devotion to quality and first class customer care.

Manufacturing matters in the UK

The central value-adding activity in any industrialised economy, including ours

- 25% of gross domestic product
- 22% of the workforce

delivering

- 80% of visible exports
- 40 % of current account credits

source: DTI

THE CUSTOMER'S CONFLICTING NEEDS AND DESIRES

If we know why people buy our product then we should be able to translate that knowledge into an understanding of what we have to do to succeed as manufacturers.

We must make every effort to look from the customer's viewpoint and we must recognise that he has many needs and desires. They are often conflicting, he looks for low prices yet expects superior product performance. He demands high quality and reliability. He wants infinite customisation—yet off the shelf availability. He looks for an instant response and back-up second to none and he'd like a 'one stop shop'. Finally, just when you've got him all set up, someone tells him about tomorrow's product and he wants it today.

Now, of course he can't have all of these things—in fact he can seldom have more than one or two and we, as manufacturers, must recognise this: for each of our product ranges and for each of our major markets we need to understand what the customer's priority is today, what we forecast his priorities will be tomorrow and therefore set out, as part of our manufacturing strategy, what it is that we have to excel at to stay in business.

In the past we had expensive hard automation therefore we needed long production runs in order to recoup the high capital cost of this equipment however, our environment is changing very fast and this approach is no longer good enough. Customers and consumers want a steady stream of innovative products, yet they expect them to be 100 per cent reliable and they mustn't be too expensive.

The customer has many often conflicting desires and needs. Attributes such as low price are now order qualifiers and not order winners; it is becoming increasingly rare that we purchase items simply on their price alone. Often there are a great many other contributing factors to be taken into account. The fundamental issue is that all of these needs and desires are influenced by innovation, in one form or another, in the design of the product and process.

The customer's conflicting desires

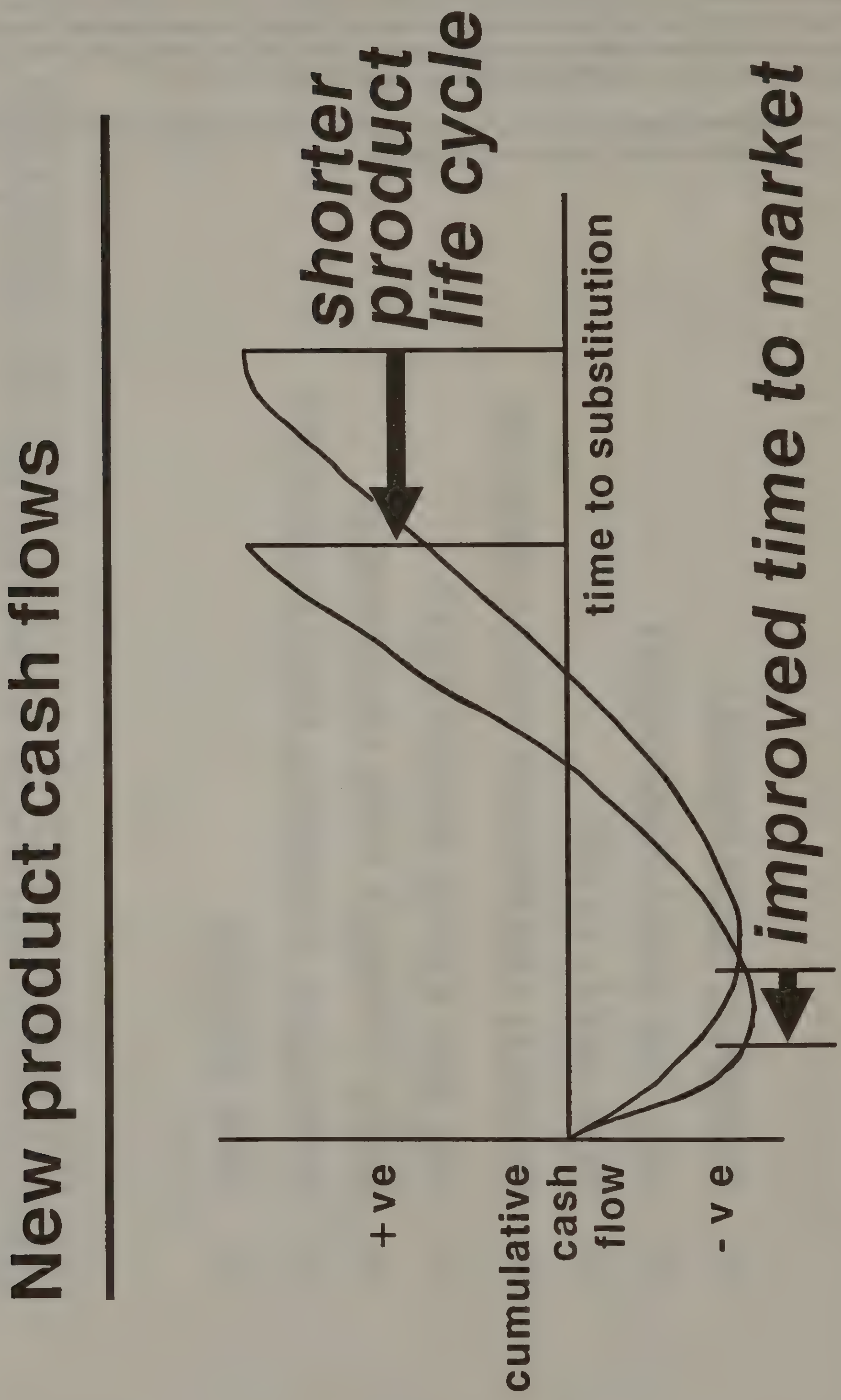
- ✓ low prices
- ✓ superior product performance
- ✓ high quality and reliability
- ✓ off the shelf availability
- ✓ instant response and back-up
- ✓ one stop shop
- ✓ infinite customisation
- ✓ product innovation

NEW PRODUCT CASH FLOW

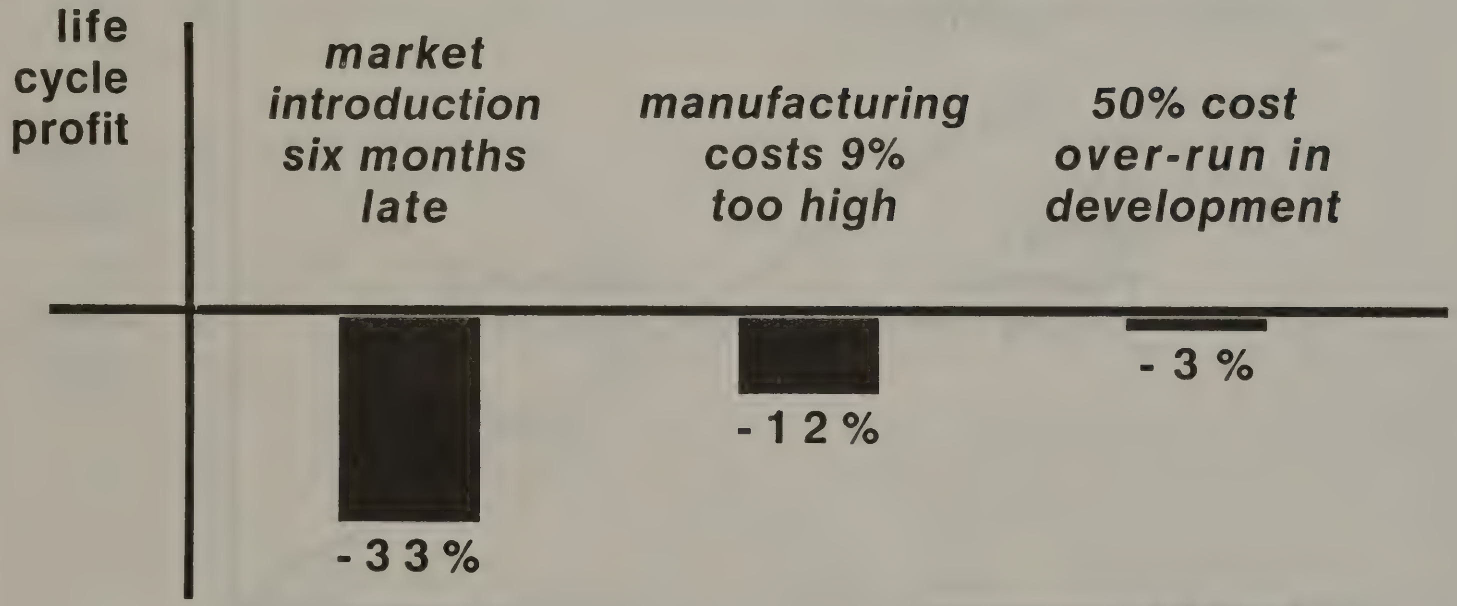
If the management of time is the new imperative, then we must recognise that money still talks loudly. World class competitors are managing time to market and since they dominate the market-place this means shorter product life-cycles for everyone.

This means that there is less time to harvest the cash before products are substituted. If we can manage that time to market better, then any improvement has dramatic pay-offs because **it is** a fact that a month won early on in the development phase (when time constraints don't seem too pressing and **lots** of projects are competing for resource) is a month's revenue won at peak production levels.

Not only that, being **first to market** gives you the opportunity to charge premium prices for that little bit longer before the competition catch up and squeeze margins.


New product cash flows
shorter product life cycle
time to substitution
+ ve
cumulative cash flow
- v e
improved time to market

Managing product development



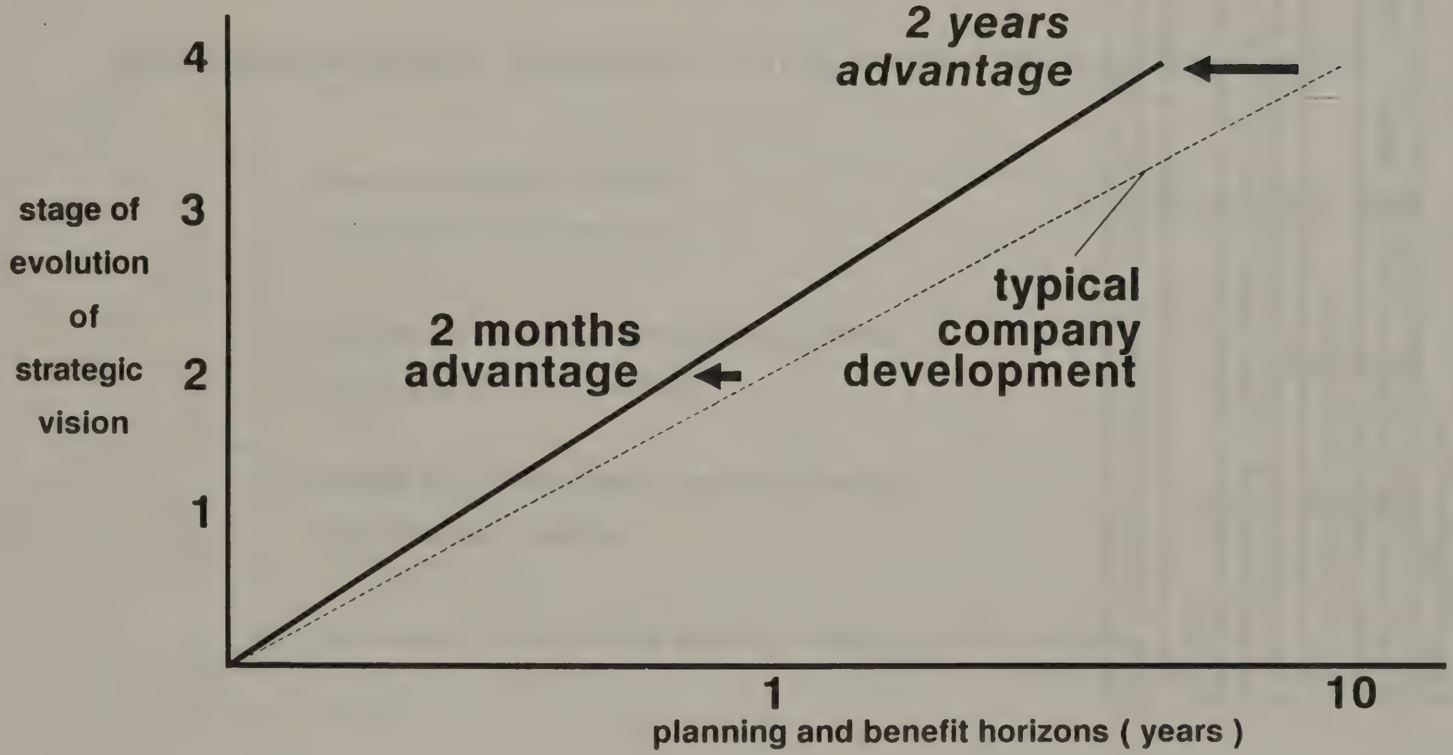
source: McKinsey & Co

THE INNOVATION GAP

The message is clear and simple—if a company does not keep up with the rate of technological innovation then it is very difficult to recover lost ground at any future stage. A company that can gain even a small innovative advantage over its competitors—whether that be in the product or the manufacturing process—has the opportunity to build upon its early lead at every stage. Those that lose out at the beginning may never catch up.

The Innovation Gap

the opportunity to achieve competitive advantage from a strategic approach to the art of manufacturing



MANUFACTURING'S ROLE IN INNOVATION

It is enlightening to examine manufacturing's role in an organisation and its role in strategy formulation. It frequently explains why there is a lack of innovation and companies are behind the game, in performance and in lack of vision.

We can position manufacturing's role on one of four tiers.

On the first tier manufacturing industries haven't changed in 10 years; don't know where they stand and are losing ground fast.

The second role that manufacturing can have reflects the grudging respect that marketing and financial people have for their manufacturing colleagues. Manufacturing is seen as "internally supportive" despite its image; have always had improvement programmes, but these have not been based on external competitive pressures.

On the third tier of development manufacturing are doing OK; they are treated as equals and have a plan to achieve a better competitive position by developing **a strategy for manufacturing** which is "externally supportive" of business objectives. Many profitable western manufacturers fall into this group and much can be achieved, though the role tends to be one of **followership,** which stifles innovation.

There are only a few organisations where manufacturing has the opportunity to take on a leadership role. It is these enlightened organisations who recognise that they can achieve sustained competitive advantage through manufacturing. By looking into the future, they aspire to be world class.

Manufacturing's role in innovation

Are we behind the game ? If so, how far behind ?

We can position manufacturing's role on one of 4 tiers

1. haven't changed in 10 years; don't know where they stand	*losing ground fast*
2. have always had improvement programmes, but not based on competition	*behind*
3. doing OK, have plan to achieve better competitive position	*not a leader*
4. advanced, world class leader, looking into the future	

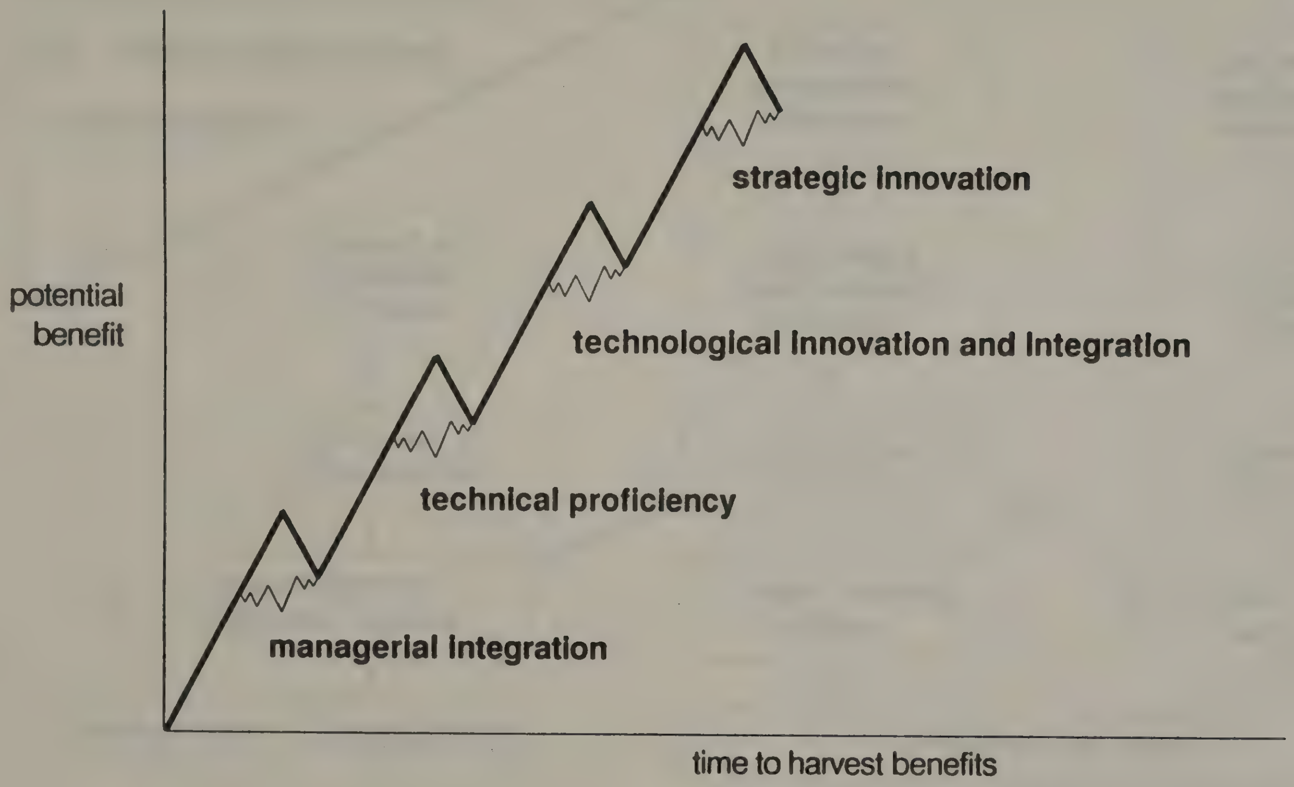
THE EVOLUTION OF STRATEGIC INNOVATION

There is no easy route to the achievement of strategic innovation, each of the four peaks of managerial integration, technical proficiency, technological innovation and integration and finally strategic innovation need to be scaled in turn.

Strategic innovation must be the goal for all successful companies. Strategic innovation:

- Reshapes the business.
- Takes nothing for granted.
- Focuses upon break-throughs in the art of product design and manufacturing.
- Builds an innovation gap; and
- Seeks market leadership.

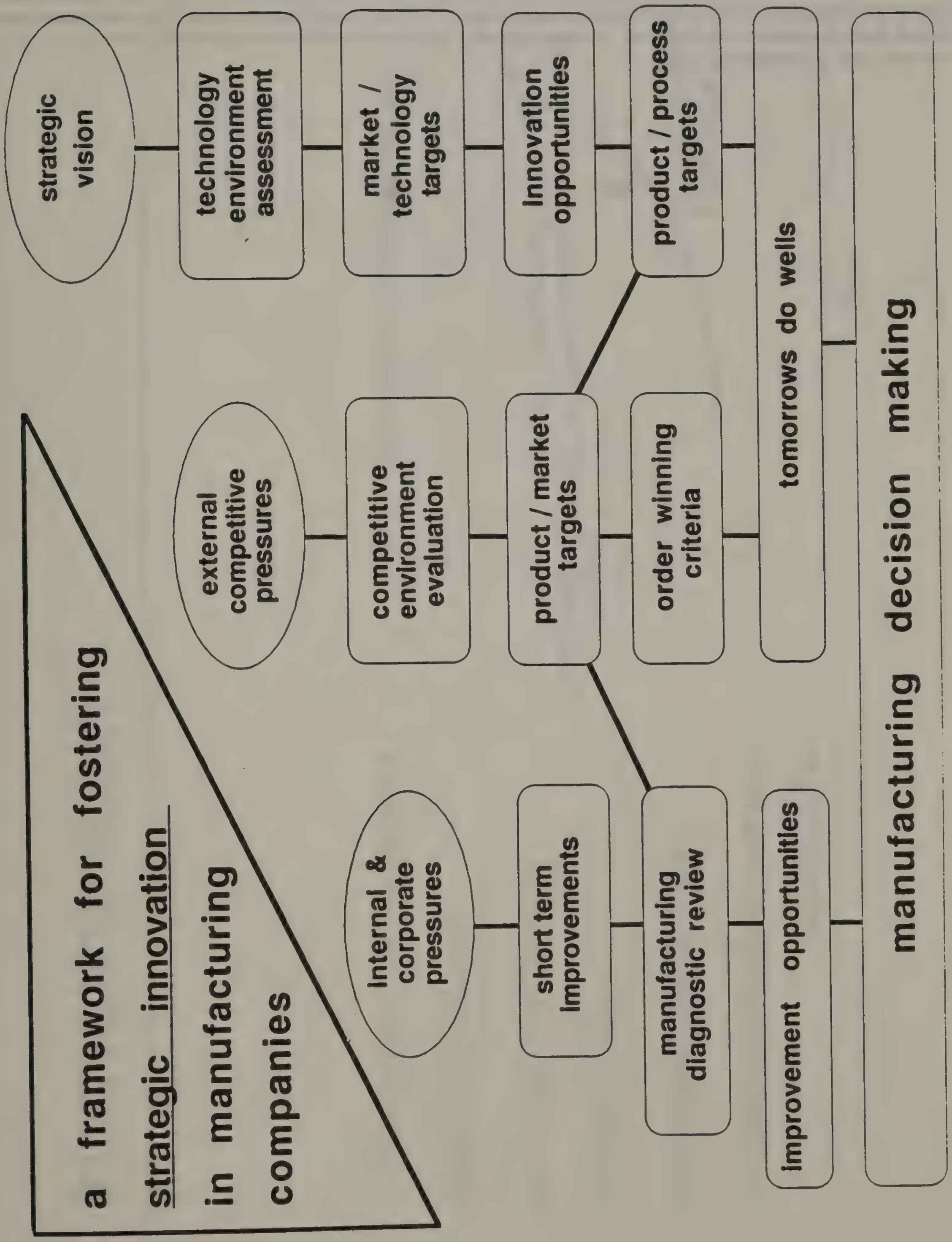
The evolution of strategic innovation



The ascent is planned as one expedition with a clear mission
Each peak must be scaled in turn - there are no short cuts.

A FRAMEWORK FOR STRATEGIC INNOVATION

Companies need a framework in order to successfully manage and control strategic level innovation. The framework must embrace: internal pressures, market pressures and technological innovation. Only by considering such a wide range of functions in a framework such as that shown can an organisation achieve the quantum change necessary with any real degree of direction and control.


a framework for fostering
strategic innovation
in manufacturing
companies
strategic vision
technology environment assessment
market / technology targets
innovation opportunities
product / process targets
external competitive pressures
competitive environment evaluation
product / market targets
order winning criteria
tomorrows do wells
internal & corporate pressures
short term improvements
manufacturing diagnostic review
improvement opportunities
manufacturing decision making

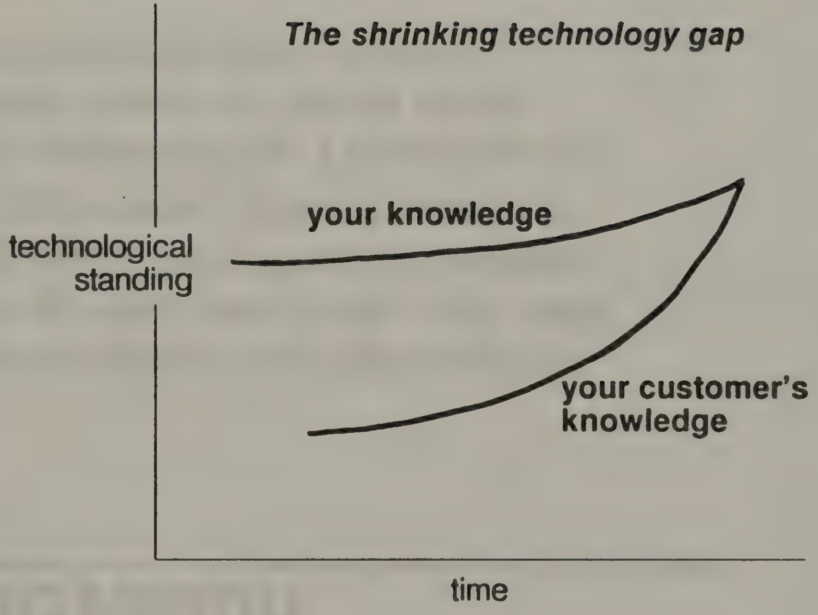
INNOVATION AUDIT

In the early days of a technology a large gap is likely to exist between knowledge of that technology held by its developers and that of their customers. This is often reflected in the high margins that exploiters of the technology are able to achieve, based on their advice to their customers. Nevertheless, customers acquire their own knowledge, through experience and development. This shows up in decreasing margins as customers become unwilling to pay for their supplier's knowledge of increasingly standardised applications. This phenomenon has been experienced in many areas. Eventually the knowledge held by customers may exceed that of suppliers. At this time the customer may source the application internally. Alternatively, he will only pay a commodity price.

Innovation audit

" The core of a company
is what it knows
and what it can do,
rather than
the products it has
or the markets it serves."

David Ford 1988



The shrinking technology gap

Systematic innovation

" Innovation is both conceptual and perceptual. Successful innovators go out and look, ask, and listen. They look at figures. They look at people. They work out analytically what the innovation has to be to satisfy an opportunity. Then they go out and look at potential users to study their expectations, their values and their needs....

An innovation has to be simple and it has to be focused."

Peter Drucker 1985

THE RISK OF DOING NOTHING

We do not have a "doing nothing" option. In the words of Francis Bacon, "He that will not apply new remedies must expect new evils; for time is the greatest innovator".

The risk of doing nothing is now greater than ever before.

The risk of doing nothing

He that will not apply new remedies
must expect new evils;
for TIME is the greatest innovator.

Essays: Of Innovations
Francis Bacon c. 1620

FOCUSED MANUFACTURING AND EXPERIENCE

Focused manufacturing is the second theme. Wickham Skinner's ideas on the focused factory have still not been universally adopted fifteen years on.

We still need to learn to focus each plant (or plant within a plant) on "a limited, concise, manageable set of products, technologies, volumes and markets". Market, product and process proliferation is the natural result of growth and success. Manufacturing must segment to regain simplicity and control. Simplicity is the goal. All big complex business were small simple businesses at one time and we should not accept today's complexity as a fact of life.

If we look at the concept of product and process life-cycles and the way they evolve then we can illustrate the concepts of focused manufacturing and **experience curve strategies** on the same picture. The picture shows product structure evolving from left to right from the early days of one-offs moving through the early stages of the product life-cycle eventually culminating in the production man's dream of a high volume of standardised products. Running from top to bottom we have the evolution of process choice, moving from a contract or project environment through jobbing and batch production finally reaching continuous flow.

Most products tend to follow the diagonal from top left to bottom right with the steepness of the diagonal depending on the efforts management put in to design rationalisation, automation, productivity and so on.

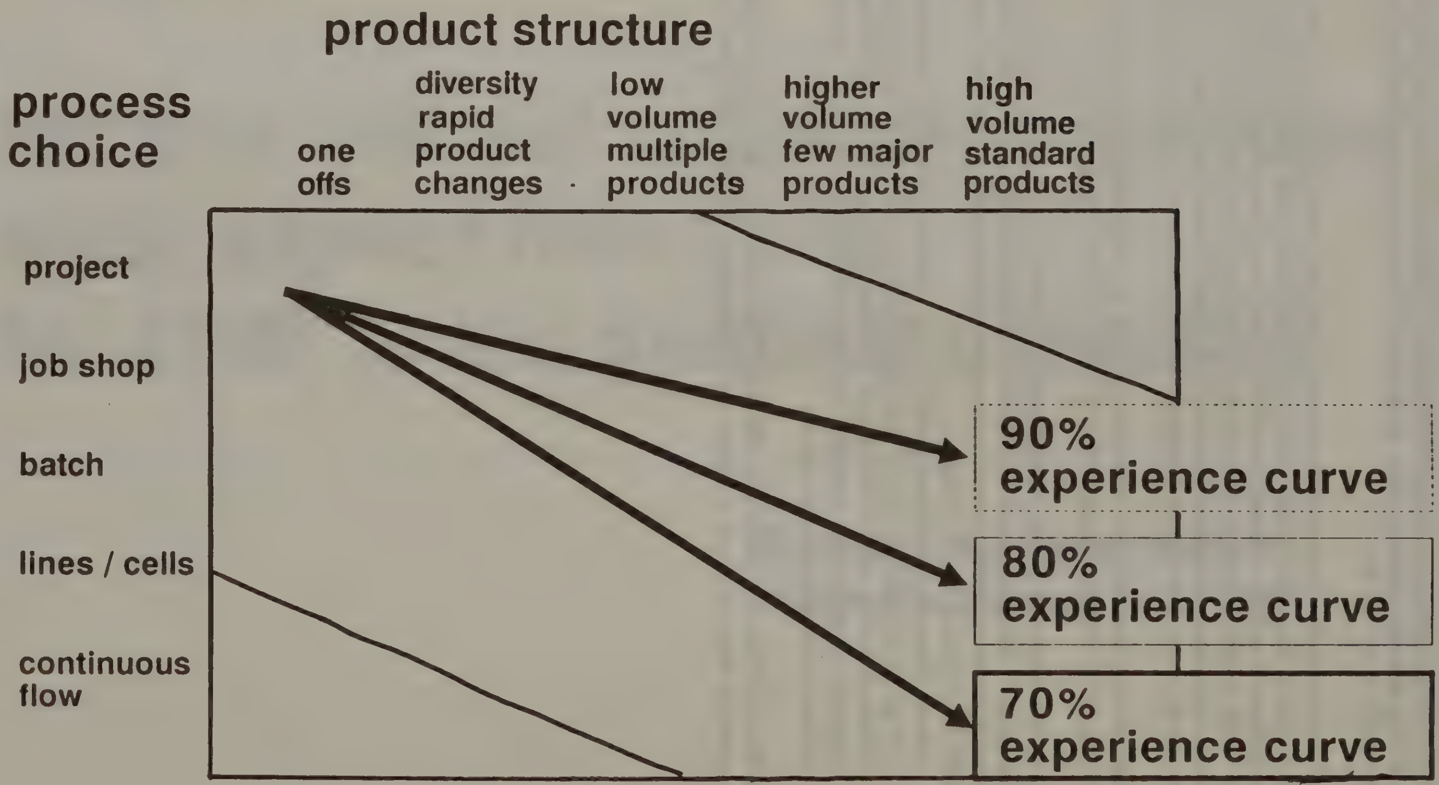
The fourth theme is **flexible manufacturing systems.** Professor Jaikumar of Harvard Business School concluded that "the new role of management in manufacturing is to create and nurture the project teams whose intellectual capabilities produce competitive advantage". He paints a picture of "a drastically altered competitive landscape which features:

A sharp focus on intellectual assets as the basis of a company's distinctive competence.
A heightened emphasis on the selection of the portfolio of projects a company chooses to manage.
A close attention to the market and to the special competence of process engineers; and
A pointed emphasis on reducing fixed manufacturing costs and the time required to generate new products, processes and programs.

The heart of this new manufacturing landscape is the management of manufacturing projects; selecting them, creating teams to work on them, and managing worker's intellectual development".

Planning for innovation

experience curve projections help us to make decisions



product structure

process choice

one offs

diversity rapid product changes

low volume multiple products

higher volume few major products

high volume standard products

project

job shop

batch

lines / cells

continuous flow

90% experience curve

80% experience curve

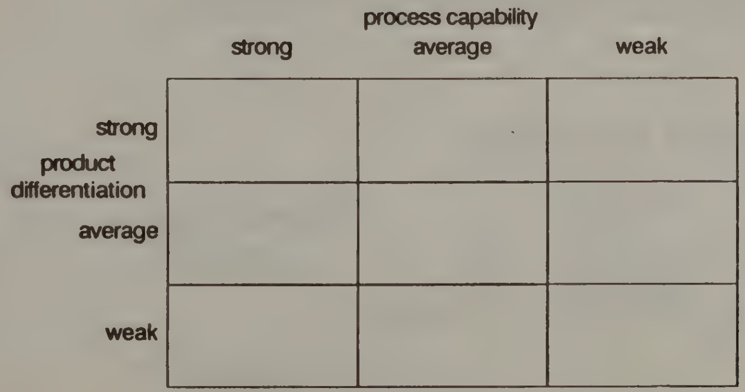
70% experience curve

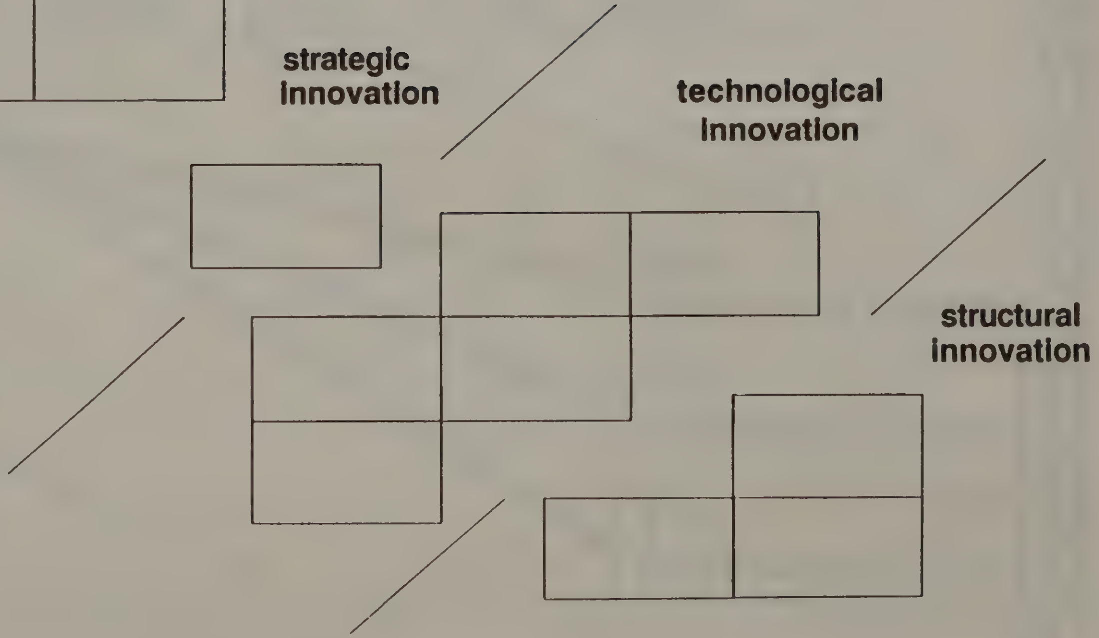
PRODUCT AND PROCESS TRANSFORMATION

Manufacturing strategy is a blend of technological, systems and people initiatives and every strategy is different. There is no prescriptive solution to transforming our approach to product/process design and evolution.

We have however shown four typical features of world class manufacturing in the box where they are likely to be important. These are simultaneous engineering, focused manufacturing, flexible manufacturing and experience curve strategies.

Product / process innovation





the approach to innovation is influenced both by the current product / process environment and the ability to transform it.

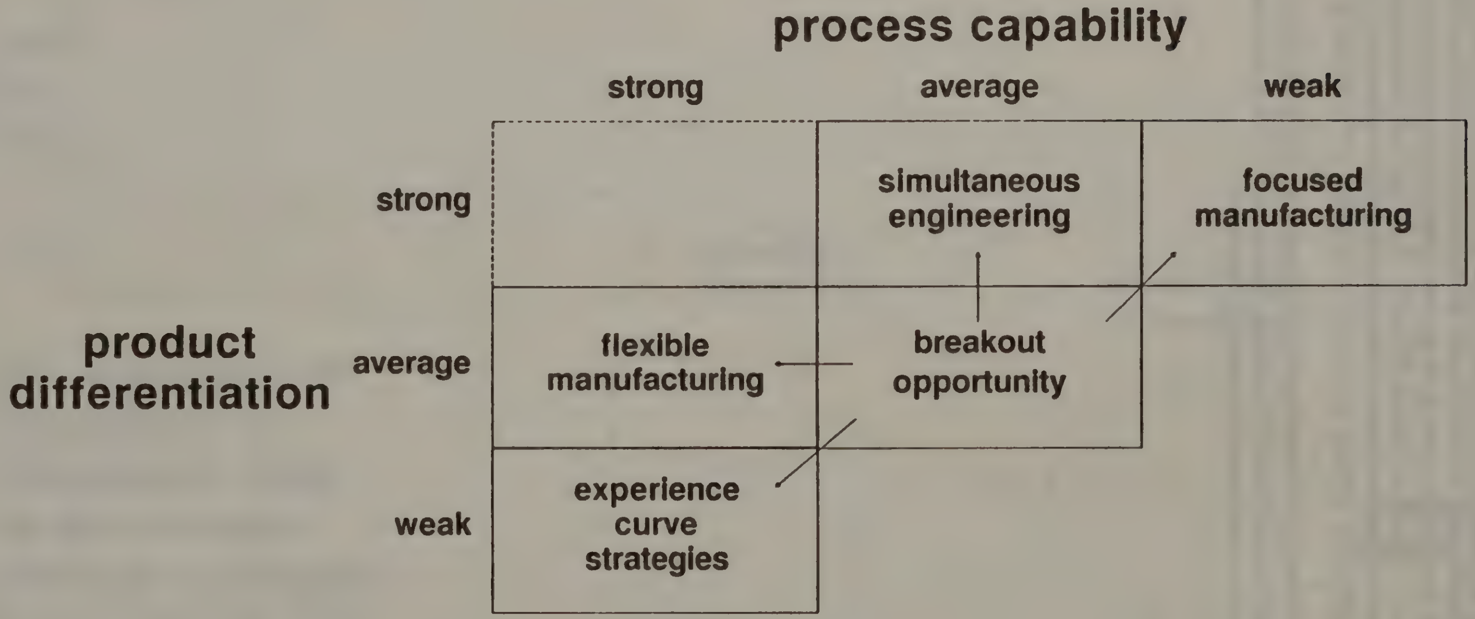
PRODUCT/PROCESS INNOVATION

One strategy tool uses a matrix which looks across the product range and identifies where we have differentiation and looks into the manufacturing operation to identify where we are strong and where we are weak in terms of the process capability.

If our manufacturing operation is strong yet our products are much the same as everybody else's, it is likely we will be striving to maintain a low cost position. Conversely, if we are strong in terms of product performance and specification yet relatively weak in production then we are likely to be supporting a differentiated position in the market place. If we are honest and have little to offer in either dimension then we may be about to enter a period of intense difficulty. If we are just about average in our industry then there is a clear opportunity. If we can devise a number of alternative strategies for specific product/market targets we have the opportunity through the use of innovation to break out of this "me too" position.

The approach to innovation is influenced both by the current product/process environment and the ability to transform it. We have the opportunity to undergo innovation at a strategic technical or structural level, depending upon our product positioning and existing capability.

Product / process innovation



There is no prescriptive solution. Transformation is likely to need a blend of techniques, technologies and new approaches.

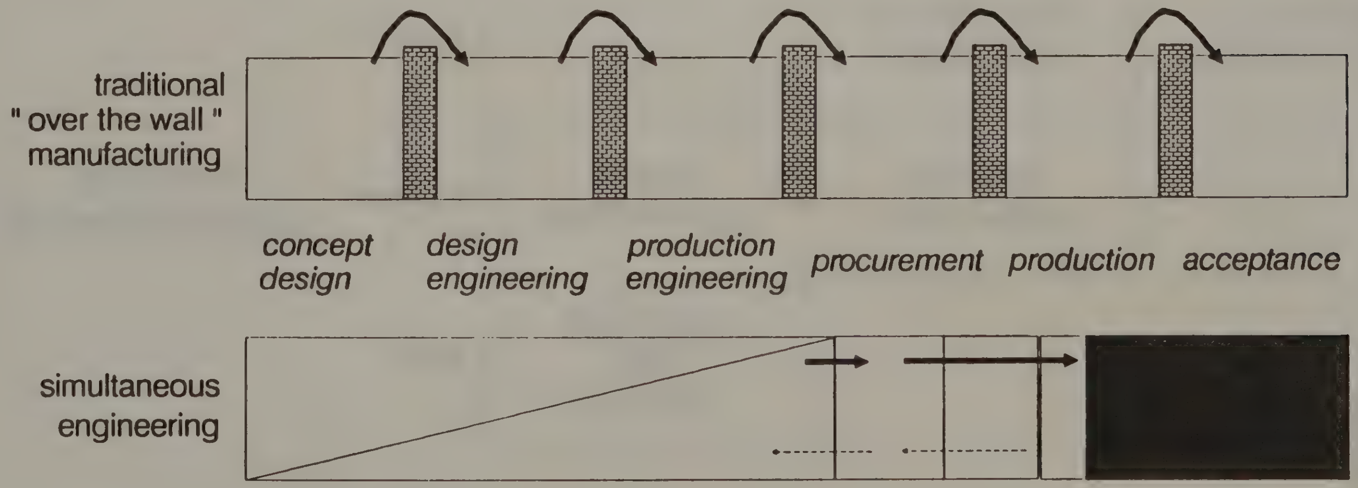
SIMULTANEOUS ENGINEERING

Maintaining product differentiation means bringing a steady stream of new innovation products or product variants to the market place ahead of the competition. Traditionally, an "over the wall" approach to manufacturing has been adopted where functional barriers inhibit progress.

With **simultaneous engineering, i.e., parallel development,** not serial development, we find that product development lead times are usually compressed by involving production, quality and test engineering right from the start. This isn't always the case but even if development may take longer, the procurement, production and acceptance phases are dramatically compressed and the customer gets a proven quality product much sooner. Such multi-disciplinary working teams create an environment for innovative changes in the product/process recipe.

Simultaneous engineering

Product development leadtimes are usually compressed by involving production, quality and test engineering right from the start. But not always ...



development may take longer but the customer gets a proven quality product much sooner.

PRODUCT INNOVATION

There are trade-offs in the choice of an innovative design over an imitative product. Both strategies have different yardsticks in terms of the level of investment required and the potential reward available to successful companies. The degree of risk varies correspondingly.

Product innovation

There are trade offs in the choice of an innovative design over an imitative product.

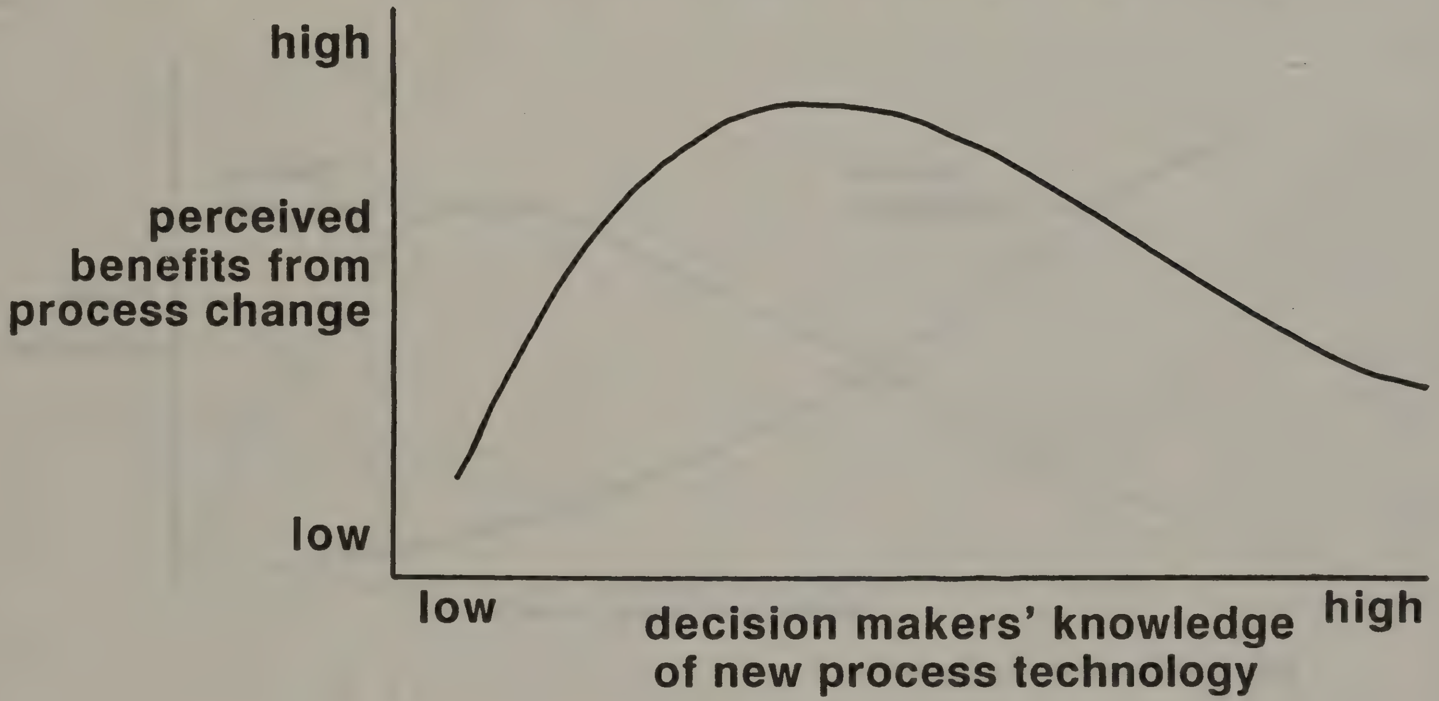
Imitative model		Innovative model
relatively well known and stable	market demand	potentially large, unpredictable, risk of a flop
rapid	acceptance and recognition	may be slow initially, responseof competitors
readily available	marketing and distribution policies	may require unique tailored policies
fit with existing market and product policies	segmentation	may cut across traditional segments
designs usually compatible	product standardisation and modularisation	may undermine successful policies
minimal risk	manufacturability	introduces large uncertainties
affords maximum use of existing investments	vertical integration and facilities	makes existing skills and commitments obsolete while requiring new investments for replacements
facilitates through streamlined designs, rationalisation and economies of scale	cost reduction	unfamiliar technology, high start up costs and production uncertainties may conflict with ongoing efforts
minimal risk	product liability and quality	introduces large uncertainties

freely adapted from Hayes and Abernathy 1980

Process innovation

Vision must be focused through knowledge

"a little learning is a dangerous thing "

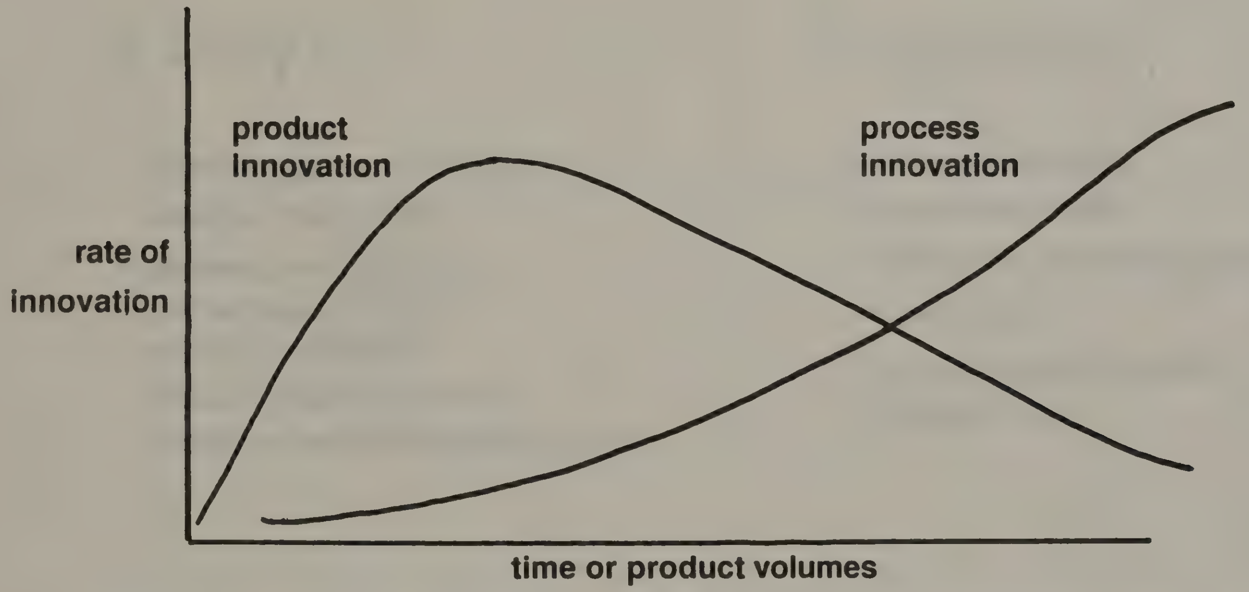


INNOVATION PATTERNS

Innovation in the product may, by itself, not be enough. Often, we must combine product innovation with equal innovation in the process. This can frequently provide a competitive edge which is more resistant to erosion.

Innovation patterns

We must seek to follow successful product innovation with equally exciting process innovations. Rising volumes of innovative products provide the spur for major process change.



Abernathy and Utterback 1975

How to prevent innovation

Innovation requires careful nurturing and encouragement. Left to fend for itself an innovative idea is soon stifled by the traditional environment. There are many road-blocks to innovation and each can impede or potentially kill off the creative and innovative spirit.

The barriers to innovation can include:

- — Departmental structures.
- — Irrelevant performances measures.
- — Inappropriate, remote support infrastructures.
- — Project ownership—problem disownership.
- — Short termism.
- — Function goals not company goals, and
- — Management attitudes.

How to prevent innovation !

There are many ways we can stifle innovative ideas

if we try to :

- take things out of context
- change the subject
- defend the status quo
- prove the exception
- nit pick on detail
- make unfair comparison
- justify unwarranted assumptions

if we confuse :

- ends and means
- cause and effect
- facts with unsubstantiated statements
- misunderstanding with disagreement

and by pretending to agree by saying yes, but ....

INNOVATION RISK ASSESSMENT

Oscar Wilde said that “an idea which is not dangerous is not an idea at all”. With any fundamental change there is a degree of risk attached. It is important to identify all the elements of risk and, where possible, to take the appropriate action to minimise the likelihood of the risk occurring and its impact.

Risk assessment

" *An idea which is not dangerous is not an idea at all* "

Oscar Wilde

Innovation in context

Technological transformation is expanding the limits
of what companies can do faster than managers
can explore the opportunities

Michael Porter 1985

Successful innovative projects

There is a distinctive flavour and feel about the way that successful strategic development projects are set up and run.

Conventional		Successful
functional orientation	objectives	business driven
delegated to board member	sponsorship	CEO + top team
technological	perspective	holistic
single discipline "over the wall"	project focus	cross functional
sequential	phases	over lapping
functional / lightweight	organisation	heavy weight / tiger team
well planned	planning	well managed
hidden, expert	problem solving	visible, multi disciplinary
rigid	control	flexible
imitative	approach	innovative
hardware	investment focus	software
financial	evaluation	strategic and financial
minimised	risk	assessed vs returns
no change scenario	base case	realistic
installation	milestone	implementation
once off, optimistic	post installation reviews	regular and rigorous
project complete	end point	continuous improvement

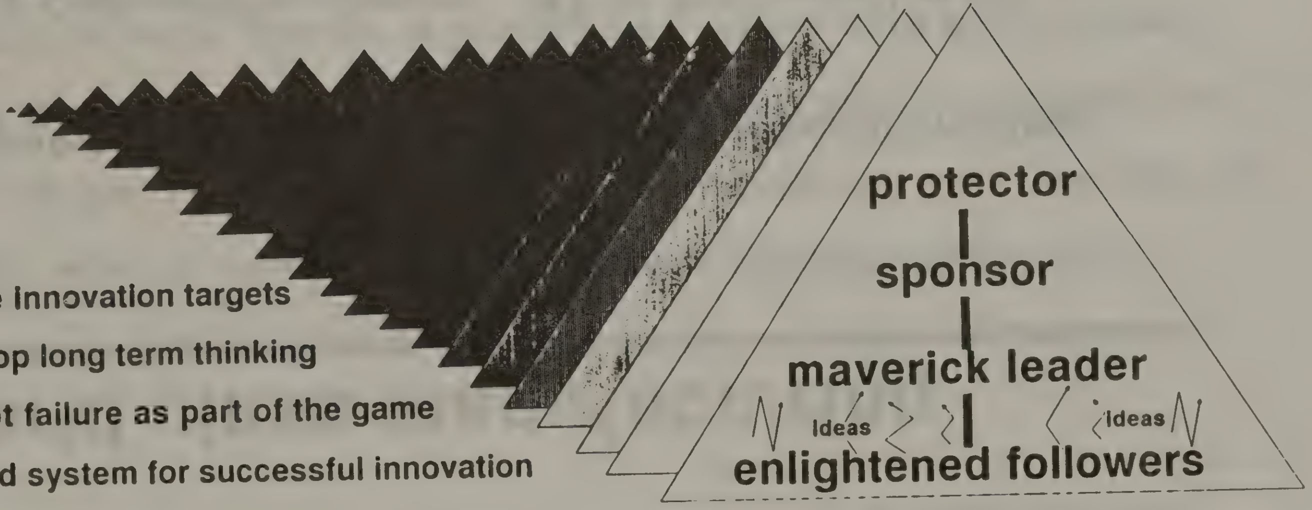
ORGANISING FOR INNOVATION

Reorganisation for innovation is essential. Good leadership and fellowship are both fundamental to successful innovation and each level in the company's hierarchy has a key role to play.

The maverick leader acts as a catalyst but cannot act in isolation: he needs to feed off ideas from those around him. A sponsor is needed to provide the innovative environment and it is fundamental that this environment is **protected** by a senior executive, otherwise the creative spirit will be dampened by the need to conform and the demands of day-to-day pressures.

Organising for innovation

Good leadership and followership are both essential to successful innovation. Each level in the hierarchy has a key role to play:



define innovation targets

develop long term thinking

accept failure as part of the game

reward system for successful innovation

protector

sponsor

maverick leader

Ideas

Ideas

enlightened followers

World class manufacturing

"we need practitioners who develop innovative ideas under competitive duress. JIT or TQC won't make a business competitive. MEN and WOMEN will."

Wickham Skinner 1988

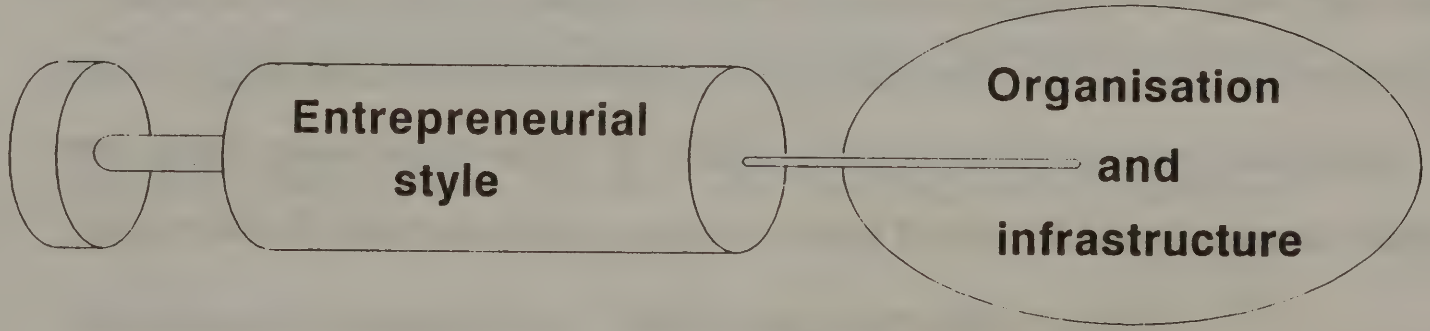
Managing innovation

" Managing innovation is like a stud poker game, where one can play several hands. A player has some idea of the likely size of the pot at the beginning, buys one card (a project) at a time to gain information about probabilities and the size of the pot, closes hands as they become discouraging and risks more only late in the hand as knowledge increases "

James Brian Quinn 1985

Managing innovation

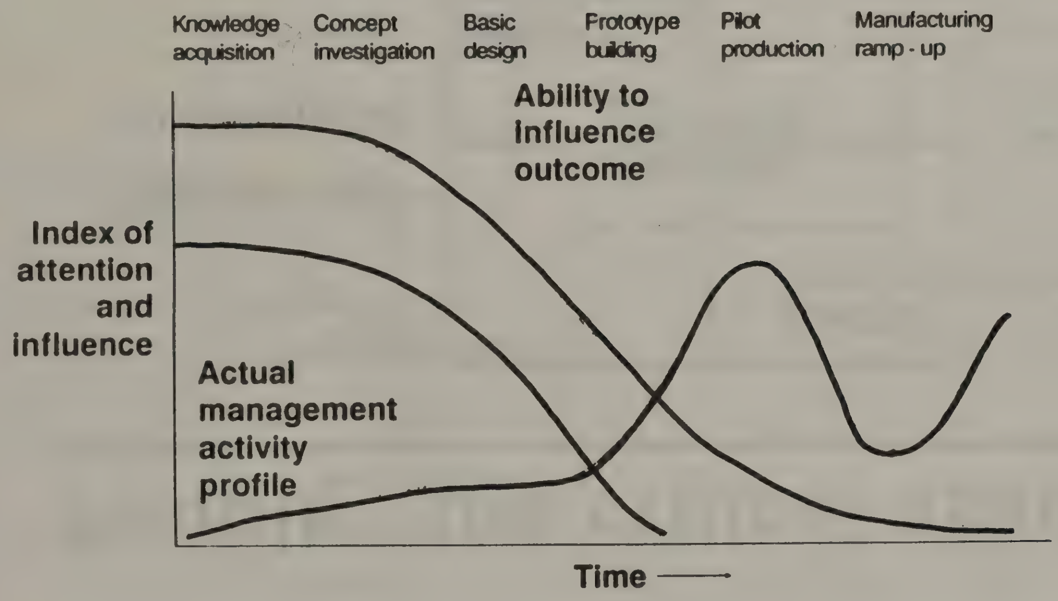
All large organisations were once small, successful enterprises. Managing innovation is about trying to get the best of both worlds.



- fanatical motivation	- committed sponsorship
- thrives on chaos and intuition	- sensible management controls
- prepared to have a go and take risks	- assessment of risks against returns
- looks long term, i.e. what people think	- recognises short term needs i.e. what the numbers say ......

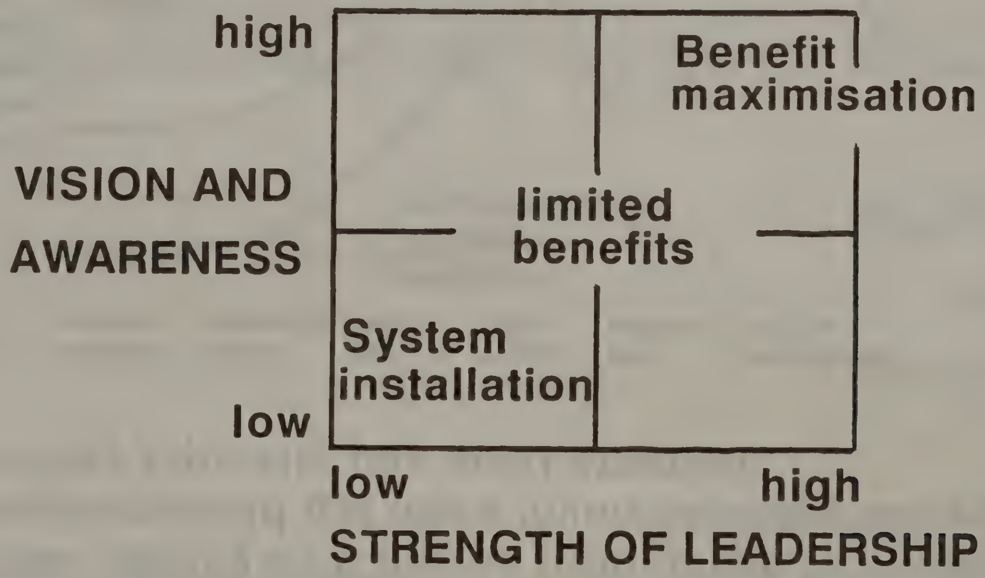
Management attention & influence

One's ability to influence the outcome of a programme declines rapidly as it moves from phase to phase. Managers should get more involved in the early phases when they typically pay least attention.



Hayes, Wheelwright and Clark 1988

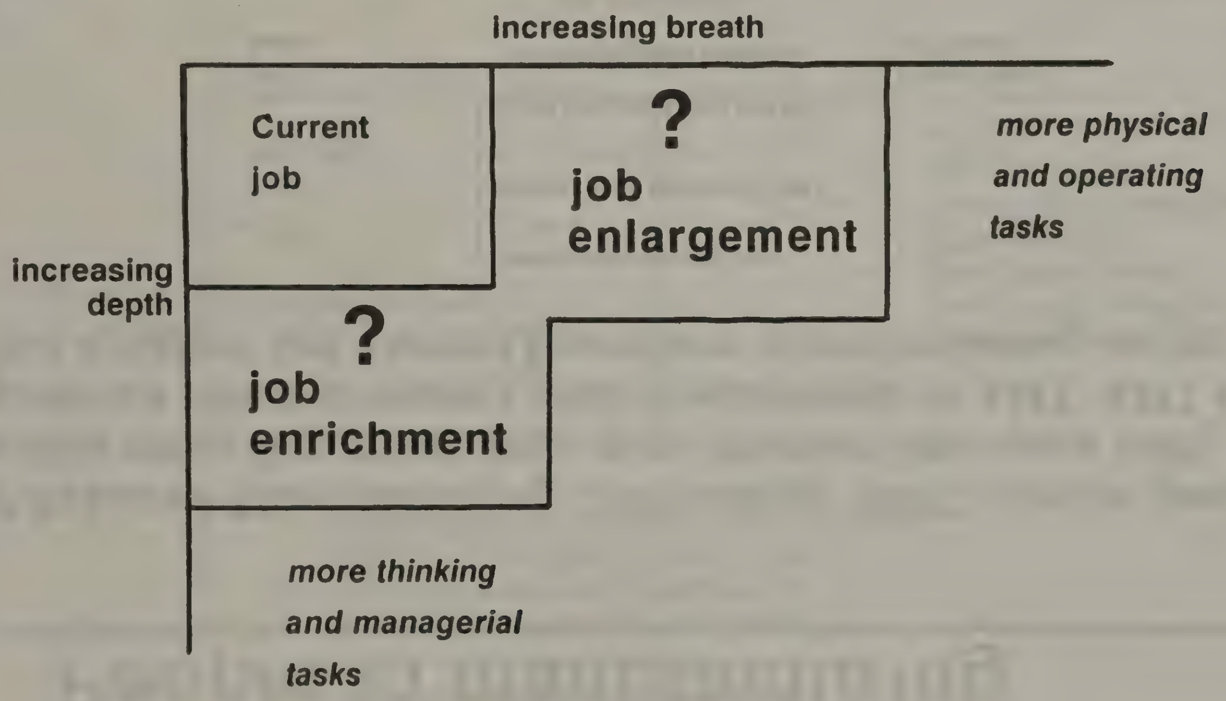
People - the critical asset



→ senior management limitations can also be a constraint

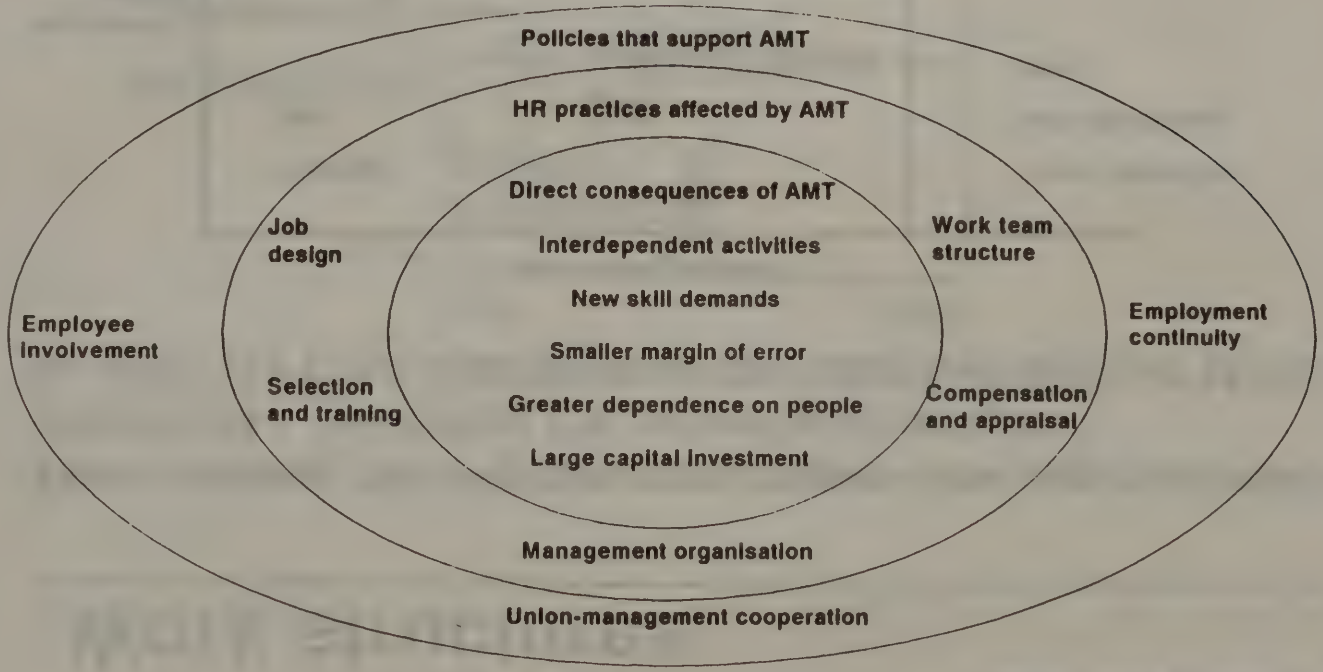
Work structures

Transforming the organisation means creating new work structures : releasing the potential of people - to motivate them and to make the best use of their skills.



People in manufacturing

Advanced Manufacturing Technology (AMT) makes people skills more important than ever. Human Resource (HR) policies need to evolve with investments in AMT. AMT can be the catalyst but cannot transform manufacturing on its own.



Policies that support AMT

HR practices affected by AMT

Direct consequences of AMT

Interdependent activities

New skill demands

Smaller margin of error

Greater dependence on people

Large capital investment

Job design

Selection and training

Work team structure

Compensation and appraisal

Employee involvement

Employment continuity

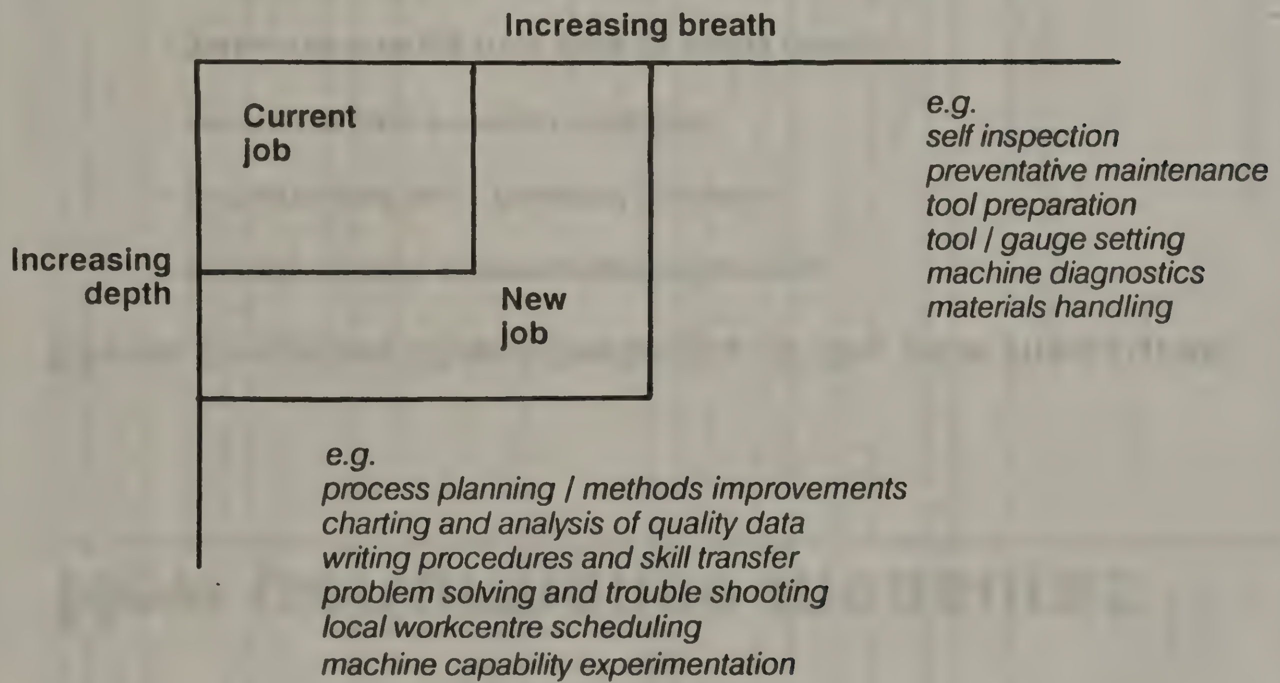
Management organisation

Union-management cooperation

Walton and Susman 1987

Job structures for innovation

innovation cannot be achieved successfully without new job structures which temper increasing breadth with the need for increasing depth of responsibility.



e.g.
self inspection
preventative maintenance
tool preparation
tool / gauge setting
machine diagnostics
materials handling

e.g.
process planning / methods improvements
charting and analysis of quality data
writing procedures and skill transfer
problem solving and trouble shooting
local workcentre scheduling
machine capability experimentation

New performance measures

Seven common characteristics of the new measures:

- directly related to manufacturing strategy
- primarily use non - financial measures
- measures vary between locations
- measures change over time as needs change
- simple and easy to use
- provide fast feedback to operators and managers
- intended to foster improvement rather than just to monitor

source: Unitronix Corporation, New Jersey 1989

SUMMARY

To bring about competitive advantage through innovation means harnessing the four strategic resources of money, technology, facilities and people, to create a manufacturing structure and infrastructure that fosters an environment of continuous improvement and Total Quality.

In this paper we have tried to indicate that:

- A healthy manufacturing industry is important to the UK.
- Today's competitive environment is very different to that of a decade ago, and that companies need to undergo quantum charge in order to remain competitive.
- There are many opportunities for innovation in both the product and process but companies need a structured framework to stimulate and control innovation and to exercise that is protected from daily pressures.
- People hold the key to achieving real innovation.

C J S BENTLEY
I P WILLIAMSON
Centre for Manufacturing Consultancy
18 *April* 1990

Letter from the London Business School

Here at the London Business School we have taken the following initiatives in the area of Business and Technological Understanding:

(a) We have, during the past year, appointed two new professors of Operations Management (Chris Voss and Terry Hill) and one result has been two new courses, one in Just-in-Time Management techniques and one on Manufacturing Strategy.

(b) We have a Centre for Design Management and, as a result of a grant from the Gatsby Foundation, we are currently advertising a lectureship in New Product Development, with a view to launching initiatives in this area.

(c) We obtained a grant of approximately £400,000 from Andersen Consulting to fund a chair in Information Management. The first incumbent, Dr Michael Earl of Templeton College, Oxford, will take up his post here on 1 January.

(d) We received a grant from the ESRC of £500,000 over five years for the Core Programme of the Major ESRC/DTI Initiative on Technology in the Firm. This is concerned with the origins, success and failure in deploying new technology and how technology can be applied most effectively to achieve competitive advantage.

I hope these comments are of some use to you.

PROFESSOR GEORGE BAIN
Principal
4 *July* 1990

Memorandum by the Machine Tool Technologies Association

We have pleasure in responding to your invitation to submit written evidence for the Sub-Committee established "to consider the pursuit of innovation in manufacturing industry".

Manufacturing has always played an important role in the UK economy—as an earner of export revenue and a disseminator of new productive techniques and innovations. Despite a decline relative to other sectors in the last few decades, the 1990s will see a greater role for manufacturing. As North Sea Oil exports fall towards the end of the decade, manufacturing will be crucial in restoring the trade balance.

The manufacturing sector must play a major and expanding role in the UK in the coming decade unless growth is to slow down or the trade deficit to widen. Large increases in manufacturing output will be needed and will require a comparable increase in investment. Market forces will deliver some of this, but will not fully provide the right incentives for this investment. This submission highlights why the market might need encouraging, and identify some key issues for policies.

Our conclusion is that much needs to be done—and that market forces including the City, whilst helping to provide more investment, will need to be supplemented by policies that are targeted towards areas where the markets may fail.

We hope that you will find our views of interest. If we can supply any further information please do not hesitate to contact us.

J F NOSWORTHY
Director General
5 *July* 1990

SUMMARY

Investment and Innovation

Manufacturing investment has a role to play in introducing and disseminating new techniques of production. Recent research has revealed that the manufacturing sector, and engineering in particular, is the main source of innovations used by other sectors in the economy. This research has also revealed the positive link between the growth of the capital stock and the spread of innovations through the economy.

Economists have long been aware that the market needs assistance in providing sufficient resources for innovations. New ideas and processes are difficult to protect. Patents help but are far from perfect.

The returns earned by the innovator are less than those received by society as a whole. Manufacturing investment plays a role at a stage where these market failures are still present. Markets will thus deliver too little investment and innovation.

Encouraging Innovation

Government policy on R&D recognises the requirement for public support of the production of ideas that are some way from the market place. However, policy should not neglect the market failures associated with the uptake of innovations. Measures designed to encourage greater co-operation between the producers of innovations and the users of innovation are needed. So too are the establishment of forums that encourage the dissemination of information and reward those that produce it.

Direct financial assistance for those producing innovations and for the uptake of innovations, possibly financed by a levy on industry, could help.

Will the market cope?

Although market forces may be very good at finding a price that will equate demand and supply for goods that already exist, they are less good at sending signals for reallocating resources through investment (in both human and physical capital) and innovations. This raises questions about current efficiency of leaving this role purely to the market, as well as about how the market will respond to changes in prices.

Too little investment in physical capital, innovation and in training will take place if these things are left to the market.

INTRODUCTION

Improving technical know-how is an activity where private profitability is frequently lower than social profitability. The private entrepreneur cannot capture in full the benefits and does not therefore receive the full social returns. From society's point of view manufacturing investment will be too low, as will expenditure on research and development. Both are crucial to the future development of UK manufacturing.

First we examine the benefits of innovation, and whether the distribution of these, hoping to answer the question "Is it the users or the producers of innovations that benefit in terms of productivity gain?" Next we produce evidence that indicates that manufacturing in major source of innovation and that manufacturing investment promotes the uptake of innovations. Finally we examine the reason why markets will not allocate enough resources to innovations and to manufacturing investment.

The Benefits of Innovation

Technical change has been shown to be the major determinant of economic growth in the twentieth century. Denison's famous study (Denison (1974)) attributed 48 per cent of the increase in productivity per worker in the US from 1929-1969 to advances in scientific and technical knowledge.

A recent study (Geroski (1988)) has attempted to investigate where the productivity gains of innovation go. Using the SPRU database[1] with a sample of 79 Minimum List Heading (MLH) industries over the period 1976-1979, the magnitude and length of effect upon labour productivity within each industry of innovations used and produced was estimated. The research found that the number of innovations produced, and that the effects of these innovations tended to be strongest for the first six to seven years and then die out by about 10 years after they were introduced.

Furthermore, examination of the source of innovations by industry indicates that virtually all of the impact of innovations upon productivity growth comes from innovations produced by the Engineering sector. As we shall see, this sector was very much a net exporter of innovations to other sectors. Innovations produced outside the Chemicals and Engineering industries do not appear to have a discernible effect upon the productivity of user sectors, and the effect of innovations produced by the chemicals sector is far weaker than those from the Engineering sector. This research is detailed in the Appendix.

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[1] This database is a count of the major innovations produced and used in the UK. It is the result of a 15 year study by the Science Policy Research Unit (SPRU) at the University of Sussex, and contains 4,378 major innovations produced and used in the UK. The sample was selected on the basis of consultation with 400 experts from academia, government and business. It is a unique sample, and is preferable to studies of R&D expenditure and paten counts because it gives information on innovations that are successful and are actually made.

The Manufacturing Sector as a Source of Innovations

Although it is impossible to observe the stock of technical know-how in the economy, we can observe additions to it by measuring the production of innovations via counts of patents and major innovations. On the latter measure, the manufacturing sector, and within it engineering in particular, emerges as the major producer of innovations, a vast number of which are used both by other industries within manufacturing, but also by other sectors such as Services.

Using the SPRU database of major innovations, it can be seen that 94 per cent of innovations included in the database were produced in the manufacturing sector. Non-manufacturing sectors of the economy were net users of innovations—they produced 138 innovations whilst using 1,642.

There are sub-sectors within manufacturing that can be regarded as "core" sectors in that they are net exporters of innovations to other manufacturing industries and to the non-manufacturing sectors. These two "core" sub-sectors are the Engineering sector (made up of Machinery/Mechanical Engineering, Electronics and Electrical Engineering and Instrument Engineering, in descending order of importance) and Chemicals. They are, in addition, net exporters of innovations and produce many more innovations than they use. Thus the four industries mentioned produced and used innovations as given in the Table below.

The Production and Use of Innovations from the "Core" Sectors

	Numbers Produced	Numbers Used
Engineering Total	2,248	595
Machinery/Mechanical Engineering	910	81
Electronics/Electrical Engineering	792	394
Instruments Engineering	546	120
Chemicals	413	167

The intensive purchase of Machine Tools in the UK are found in these sectors: indeed Machine Tools itself is found in the category that is the greatest net exporter of innovations to other sectors. Closer examination of the SPRU data indicates that Machine Tools produced 196 innovations and used 23: of the innovations which it produced it used 10, and hence it "exported" 186 innovations and "imported" 13.

The role of Investment in the Innovation Process

This points to the Engineering sector as being the source of innovations that enhance productivity in other sectors. This sector is the producer of capital goods—which are in turn the subject of investment in plant and machinery by manufacturing firms. It is here that we see the link between investment and innovation.

Research carried out by London Economics has found a link between investment and innovation. Given that an industry uses innovations, there is a positive relationship between the rate of growth of the capital stock and the number of innovations used by that industry. This relationship is strong but not very precisely estimated: it does suggest, however, that a 10 per cent increase in the rate of growth of the capital stock leads to an increase of about seven in the number of innovations used in the long run. This research is detailed in the appendix.

Will Markets Allocate Enough Resources to Innovation and Investment?

Economists have long realised that the production of ideas and new techniques may be an area where markets fail to work properly. New products and processes, once developed, are vulnerable to imitation. Patents are one way of protecting them, but are far from perfect. It can be easy to design around patent, and litigation to enforce patents can be extremely costly, especially when carried out across international boundaries. The developer will fail to capture all of the benefits from their innovative activity.

Empirical studies of the extent of the wedge between private and social rates of return indicate that they can be very substantial (see Gaff (1988), Mansfield *et al* (1977) and Berstein and Nadiri (1989)[1]). Bernstein and Nadiri estimate that the percentage difference between the net social and private rates of return varied substantially for a selection of US industries, being as high as 123 per cent for Petroleum and 30 per cent for Machinery. Gaff estimated that on average the social return on R&D capital was 40 per cent higher than would be the case in the absence of spillovers. Again, this result was for the UK but there is no reason that this result should not hold for the UK as well. Research also indicates that patents are ineffective ways of protecting the benefits that arise from innovations.[1]

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[1] These studies may in fact underestimate the extent to which spillovers occur. The study by Gaff, for instance, assumes away the possibility of inter-sector spillovers: which seem to be important judging by the SPRU data.

This evidence indicates that the rewards for innovation are not fully captured by those who undertake it. Manufacturing investment also has a role to play in innovation, and at a stage where the market failures are still present. This strongly hints that the market will not allocate sufficient resources for either innovation or investment.

Encouraging Innovation

Government policy on R&D recognises the requirement for public support of the production of ideas and innovations. Over the last few decades the UK Government has encouraged R&D by direct assistance.

In recent years the emphasis has been shifted on to providing assistance for ideas that are some way from the market place. Basic research which is directly less marketable is to be the focus of support. This is the rationale behind the Alvey programmes and the co-operative research programmes operated by the EC.

Such research does need some form of assistance—whether through direct government subsidy or through encouragement of co-operative ventures undertaken and financed by industry. However, there are two sides to innovation—the production of ideas and innovations and the uptake of these by user industries. Current Government policy concentrates on the supply side and not on the demand side. Policy should not neglect the market failures associated with the uptake of innovations.

What could the Government do to tackle these? There are a range of policy measures it could examine:

- Encourage closer links between users and producers of innovations.
- Direct subsidy to innovators or purchasers of innovations.
- Government procurement schemes could help to develop new industries.

We will examine each of these in turn.

Tightening the links between the users and the suppliers of innovations could be encouraged by establishing forums and institutions that encourage the dissemination of information and reward those that produce it. This is clearly another measure that will bear fruit in the long term: but this does not mean that we should not start thinking about it now. These types of market failure can be solved by institutional mechanisms; but the market failures are quite fundamental and will take time to cure.

Direct subsidy for both R&D and for the uptake of innovations would, at least theoretically, boost the spread of innovations through the economy. Measures designed to boost the uptake of innovations would also boost the level of investment. However, this option raises problems:

- How will it be financed? The Government may not wish to fund it out of current tax revenues. One method of financing would be a general levy on industry, to ensure that they all bear the costs of R&D as well as receiving the benefits.
- How will R&D and innovations be defined for the purposes of the scheme? It is not obvious that the definition would be tight enough for the scheme to genuinely enhance R&D efforts, and this may count against it.

This highlights that any proposal based upon a tax/subsidy scheme will require very careful specification to be taken seriously by policy-makers.

Procurement policy has been used very effectively in other countries to develop new industries and technologies. A good example can be found in the USA: the Department of Defence operated a procurement policy that accelerated the development of the US Semi-conductor industry. The guaranteed market from the Government meant that the industry did not have to rely on the private sector to bear the risks and costs associated with the development of these in industrial use. It is a good example of how this policy can be used to promote the uptake of innovations. However, we should again be aware that there are problems associated with this policy. The first is that much of it will be done by Defence departments—as they are one of the chief Government buyers of advanced technology. Defence R&D in the UK is already high —compared to industrial R&D—and may not need much more encouragement. The Government does buy other technology-intensive goods—such as new drugs for the NHS—but inasmuch as the demand patterns of the Government are different from those of manufacturing industry, we must question whether this is a viable policy option.

Secondly, the benefits of procurement should reach as many firms as possible: this implies that procurement policies should specify a high degree of sub-contracting on the part of the major supplier.

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[1] Levin *et al* (1988) surveyed 650 R&D managers from 130 lines of business in the USA. They found that, on a scale of one to seven in ability to protect the profits from innovation, only 20 per cent of respondents rated patents higher than a 4 for new processes and although the rating was higher for new products, in general few managers felt that patents were effective.

Encouraging the production and uptake of innovations would both increase investment and benefit UK manufacturing.

APPENDIX

The Relationship between Investment and Innovation

The sample was 79 three digit industries (or, MLH—Minimum List Heading) for the UK. The data was stacked into a panel for four years, 1976-1979. This gave a total of 316 observations.

The dependent variable was the number of innovations used in each industry in each year. The count of innovations came from the SPRU database described earlier.

The explanatory variables were:
- 79 industry dummies.
- Three time dummies.
- The rate of growth of the capital stock GK(t).
- Lagged dependent variable IS(t).

The main problem facing this research was that many industries did innovate in this period. Thus two regressions were run. The first sought to explain what factors were important in making an industry innovate; the second was to explain, given that an industry innovated, what factors determined the number of innovations used.

The first regression was thus a Probit, the dependent variable taking the value 1 if the industry innovated and 0 otherwise. The equation found that the important factors in determining whether an industry innovated or not were the number of innovations used previously, and industry dummies.

The second regression was an Ordinary Least Squares regression run for the subsample of industries that used innovations. This found that the rate of growth of the capital stock was a significant determinant of the number of innovations used. The results suggested that a 10 per cent rise in the rate of growth of the capital stock is likely to increase the number of innovations used in the long run by around 4.0 Given that the average number of innovations used per industry in this sample was 2.86, this is a substantial increase. A correction for sample selection bias was performed.

In the equation, lagged innovations have a negative sign—as does the current growth rate of the capital stock. This should not be interpreted as meaning that these variables reduce the number of innovations used. The reason for this is that the industry dummy picks up the mean of the number of innovations used. Hence the negative signs on these indicate that they reduce current innovations below the average; they thus affect the timing of innovation use, rather than the average number of innovations used.

Who gets the productivity benefits of innovations?

Research by Geroski (1988) has revealed that the industries that use innovations receive the productivity benefits of innovations. That this should be so is not clear from economic theory. If all the increase in knowledge is embodied in the new product/process then it is not surprising that the user industries should receive these benefits. But equally, what could matter is the research and engineering done during the production of a new innovation, because the stock of productive knowledge is increased in indirect ways during production.

The sample used was identical to that used in investigating the relationship between investment and innovation. The dependent variable is the rate of growth of labour productivity. Output is measured by an index of real output based on shipments; labour is the number of full-time people employed. Amongst the dependent variables were the rate of growth of capital per unit of labour, current and lagged innovations used and produced in that industry, and industry and time dummies.

The result was that the number of innovations used had a much greater effect on productivity growth than the number of innovations produced.

A further sectorial analysis was performed that looked at the relative importance of innovations produced in the Engineering and Chemicals sectors. The result of this was to show that virtually the whole effect of innovation use is due to the innovations used in the Engineering sector.

Supplementary Memorandum by the Machine Tool Technologies Association

The period from 1946-70 saw a boom period for the UK machine tool industry resulting from the destruction of the traditional competitors in Europe during the war. Until 1956 the UK remained second to the USA but by then the FRG had regained its position as the leading machine tool producer, a position it still holds.

By 1960 other competitors began to emerge, the most noteable being Japan, who deliberately selected a narrow band of tools which would have a high demand, i.e., CNC machines. With these high technology, high quality machines they threatened the traditional manufacturers including West Germany.

The decline of the UK industry which began in the 1970's must be seen against this background and the worldwide recession which occurred at the end of the decade. In 1983 home market demand stood at 45 per cent of the level in 1979. By 1984 the market for exports to the United States had fallen to 57 per cent of the level of 1978. The major problem facing the industry was a massive fall in manufacturing output not only in the UK but throughout the world. However, throughout the UK there existed problems which could not be blamed on the world recession:

1. Poor management.
2. Poor marketing skills.
3. Obsolete technology.
4. Poor quality.

These endemic problems were compounded by a number of short-term economic failures which only exaggerated the situation. Poor industrial relations, high wage claims, high inflation and a strong pound meant that the UK suffered more than most from the worldwide recession.

The ability of UK manufacturers to compete in this period was severely hampered by the low levels of investment in the proceeding years. By the early 1970's investment in machine tools/employee was $560 a head compared with $1,810 in West Germany, $1,560 in the United States and $1,080 in Japan. This was part of the problem which meant that competitors could produce more sophisticated machines at a more competitive price than UK manufacturers at a time when there was a severe case of worldwide over capacity.

Unable to compete many UK firms simply disappeared without trace. The UK industry was being squeezed at the high technology end of the market by Germany, Japan, Scandinavia and the USA, and at the lower end of the market by developing countries such as India, Taiwan, and Brazil who had lower Labour costs enabling them to undercut prices of simple machines.

It is fair to say that had the UK machine tool industry failed to adapt to the changing conditions it could have disappeared altogether. By 1980 it was presented with a *fait accompli* by the new Conservative government that it would have to put it's house in order if it was to survive for the industry would not be bailed out.

By 1984 the number of people employed in the industry had halved from 47,000 in 1970 to 23,500. Obsolete manufacturing techniques had been replaced by new advanced computer technologies, management had improved and consequently UK firms were able to offer modern and advanced products at a competitive price which could match the traditional and emergent competition. This recovery was helped by the increases in manufacturing output not only in the UK but throughout the world which provided a strong demand for machine tools, in the aerospace and automotive industries for example which enjoyed boom periods. By 1989 sales of UK machine tools had risen from a low of £414 million in 1983 to £990 million in 1989. In the same period exports had risen from £210 million to £399 million.

It has been stated that short-term economic problems had aggrevated the situation in the late 1970's. However these fractures had been tackled by the mid-1980's and their absence was helping to promote recovery. Industrial relations had been improved by curbing union power through legislation and the natural effects of the shakeout of labour. Interest rates and inflation had also fallen and compared favourably with those of our competitors.

The UK now exports approximately 45 per cent of total output and has the sixth largest market in the world. Exports for January to September of this year show a 27 per cent increase on the corresponding period last year of which half is accounted for by CNC machines. The UK now accounts for 3.8 per cent of world output as opposed to 4.7 per cent in 1970

MARK SWIFT
28 *November* 1990

Letter from Manchester Business School

Thank you for your letter asking me for my comments on the *scarcity of individuals with both business and technology understanding* and the *initiatives being taken by business schools to overcome this scarcity*. I am pleased to have the opportunity to comment on this as it is an area in which I have been undertaking research recently. Before commenting on specific recent initiatives it is probably worth placing the issue into a rather wider context.

These shortages are long established in this country. They can be seen elsewhere, notably in the USA. West Germany, Japan and Scandinavia probably have the best record in tackling the challenge of developing individuals who combine both business ability and technology understanding.

The problem tends to be especially acute during times of rapid technological change. These periods are especially challenging to business executives who fail to appreciate the potential and risk embodied in technology. At the same time, those technologists without proper business guidance fail to realise the full, commercial potential of their innovations. The mid-1970s saw a burgeoning recognition of this problem in the USA and Britain. Both were suffering from relative declines in industrial productivity. This was linked with a failure to exploit technologies which were emerging from research in the Universities, research institutes and advanced companies.

This was highlighted by a series of studies by the National Science Foundation in the USA and project Sappho in Britain. Presidents Carter and Reagan encouraged Universities to bring together their Business and Engineering faculties in collaborative projects. Among the most successful of these initiatives were the Innovation Centres and Incubator Centres established at a wide variety of US Universities. Typically, these were run jointly by the two faculties. Specialist internships for undergraduates, doctoral programmes and research institutes emerged from this programme. It would be fair to say that the US is now benefiting from these initiatives.

In the UK the response has been much smaller in scale and far more localised. The traditional barriers between disciplines and faculties has been reinforced, resource shortages persist and there is a lack of any significant interest among policy makers. Despite that, some notable initiatives have occurred. It might be useful if I attempt to review these by surveying work across the country, initially among Universities, then Polytechnics and finally the two national Business Schools. I'll start in Scotland and work down the country.

Among the first and most long established is the MSc in Technology Management run jointly by Dundee and Stirling Universities. Although this was originally created as a Masters in Technological Economics (at Stirling) it soon adopted a strongly managerial focus. The more recent link with Dundee has enabled the strong Business School at Stirling to work effectively with a large Engineering School. The numbers involved are fairly small. The intake is less than 40 per annum with a high proportion of non-UK students. The same Universities are linked in the Manufacturing Engineering initiative at undergraduate level.

Strathclyde houses the other major Business School in Scotland. It has an admirable record in linking Business, Engineering and Science in undergraduate studies. The strongest associations have generally been through the marketing group. More recently the Design Management Initiative based at Strathclyde and Glasgow Universities has provided a powerful focus for such links.

In Northern Ireland, the University of Ulster has been very active in linking business and engineering. There are particularly strong connections in shortage areas like Information Technology. The University of Ulster was among the first to direct significant efforts at tackling the scarcity of individuals with these combinations of skills in small- and medium-sized firms.

In the North of England, Durham University Business School has a valuable collaboration with the Faculty of Engineering. They work together on the M.Eng and the final year of the first degree in Engineering. UMIST is probably among the foremost Universities at integrating Business and Engineering. Both the M.Eng degrees and certain of the specialist masters degrees in management at UMIST bring engineering and management studies together. At Liverpool the industrial studies group make selective inputs into engineering programmes. Sheffield University has recently restructured it's Business School. This appears to be being used as an opportunity to link business, science and engineering programmes more extensively.

In Wales and the Midlands, the centres for initiatives are probably Cardiff, Aston and Warwick. Cardiff seems to be concentrating its efforts on tackling this shortage through inputs from the Business School into Engineering and Science Degrees. Aston has a portfolio of good, combined degrees. The applied PhDs at Aston have been especially important at developing in-depth appreciation of the demands for business ability and technological understanding. Until recently it would have been hard to find any institution undertaking more initiatives in this field than Warwick. These have occurred at undergraduate and post-graduate levels.

The new MBA at Cambridge has placed a special emphasis on producing graduates who can combine an understanding of technology and business. The innovative design and investment in quality of delivery seems certain to place this programme to the fore in this field. Cranfield shares this commitment. The success of the MBA has made extensive links harder to develop.

Imperial College, Brunel and Bath seem to be working in distinct ways to tackle this problem. Imperial is the natural home for a strongly technological orientation. It has a good Business School which has recently restructured its Masters programme. This ought to be capable of making a major contribution to tackling this issue *if the temptation to look to the City is resisted.* Brunel has been an innovator in manufacturing studies and links between management and engineering. Bath has followed a broadly similar route.

Overall, the Polytechnics and the Central Institutions in Scotland have been more active in tackling this issue. Robert Gordon's Institute, Paisley College, Napier College and the following Polytechnics; Newcastle, Manchester, Lancashire, Sheffield, Trent, Leicester, Wolverhampton, City, Thames and Portsmouth have strong reputations for work in the field. They have been especially active recently in tackling the specialist difficulties in particular industrial sectors.

Before commenting on work at the two national Business Schools it is probably worth bringing to the committee's attention the Project Jupiter initiative. This is a large-scale effort to create a Distance or Flexible Learning Masters programme in Technology Management.

It is perhaps inevitable that of the national Business Schools, Manchester sees itself as having a particular responsibility in this area. It is located in a part of the country which is especially dependent on manufacturing, technology and science. More of its MBA graduates take up careers in industry (as opposed to commerce or consulting) than any of the other leading European Business Schools. The MBA, notably the project work, has always sought to link business ability to technological understanding. The R&D Management Unit was the first in Europe. The European Creativity Centre has a powerful, technology bias.

Recent initiatives to tackle the shortcomings you have identified have occurred in all four spheres of the School's work: Masters programmes, executive education, research and staff development.

> The School decided to build on the strong, technology orientation of the MBA by developing a new part-time Masters in Management. This has been developed in collaboration with a consortium of companies notably; Shell, Pilkingtons and BNFL. The need to develop individuals with business ability and technological understanding is central to this programme.
>
> A range of executive courses has been developed to provide specific inputs to serving managers. The most recent initiatives are in: Managing to Meet New Quality and Technical Standards; R&D Management; Design Management; Effective Operations; Environmental Management Programmes. These look like becoming important additions to our existing portfolio.
>
> Research in this area has concentrated on; Manufacturing Management; Technological Innovation and the Small- and Medium-Sized Firm and Managing Information Systems and Technologies. These are valuable supplements to the work in R&D and Creativity mentioned above.
>
> The Council of the School has decided to reinforce its commitment to overcoming the shortcomings of management in manufacturing companies by allocating extra resources and investing in new staff. We expect to make new Professorial appointments in Manufacturing Management, Operations and R&D. Naturally these will be backed by further resources.

I am confident that a similar array of initiatives can be identified at London Business School. They have recently appointed Chairs in Manufacturing Management. Several research institutes at LBS have a strong technology or manufacturing orientation.

I have tried to give a wide ranging overview of recent developments as far as I am aware of them. Many are exciting and interesting. We ought NOT to be deceived by the number of initiatives. Most are small; virtually all are under-resourced. The largest consist of a small number of committed staff. I doubt if there are more than five chairs in Manufacturing in Business Schools, Chairs in Technology Management or other specialist areas like Resourcing (purchasing), R&D, Project Management, Quality Management might be found in one or two institutions. This reflects the overall pattern of resourcing in the area.

I hope you find these comments useful. If you require further information please do not hesitate to get in touch.

Professor TOM CANNON
Manchester Business School
23 *July* 1990

Memorandum by the Medical Research Council

Q7 *How effective are the mechanisms for technology transfer from HEIs, Research Councils, and public laboratories to manufacturing industry?*

The Medical Research Council has always been concerned that benefits from its research and inventions are passed on to parents as soon as possible and that new techniques and instrumentation are made widely available to the scientific and industrial community. To this end it has been the Council's policy to ensure that its intellectual property, inventions and know-how are exploited in the national interest. To facilitate this, the MRC has forged links with industry and commerce, both to undertake joint research on problems of industrial importance and by licensing its inventions to suitable companies for the manufacture of products. In the past such links were managed exclusively by the British Technology Group (BTG) and resulted in a number of commercial developments. More recently MRC has worked with a variety of partners and agencies and the commercial development of several notable biotechnology innovations, such as the antibody engineering technologies, have been managed by the MRC directly.

Mechanisms in use

Technology transfer is managed at MRC by the Industrial Liaison Group, ILG, set up in 1982. This group, which is part of the MRC Head Office:

— Administers an incentive scheme for inventors (the Awards to Inventors Scheme).
— Negotiates industrial contracts and (for most MRC Units) collaborative research agreements (there are currently 51 such projects).
— Handles the patenting, marketing and licensing, (or assignment), of MRC inventions using external patent agents or legal advisers.

Such a group is considered to be an effective mechanism and can be self-financing. MRC is currently planning to expand the proactive role of the group. Historically, there has been a "predevelopment gap" in research relevant to innovation in the manufacturing industry, i.e., a gap in the spectrum of basic research through to development work which is neither the province of public-funded academic research nor of the commercial organisations. The MRC therefore identified a need for a specialist technology transfer activity focusing on predevelopment science, a concept welcomed by British industry which saw an opportunity to exploit and gain from MRC research. To help bridge this gap the **MRC Collaborative Centre** was set up in 1986. It markets MRC ideas which have the potential to be developed commercially but require further development work and enters into collaborative research agreements with an industrial partner. It is responsible for the patenting and exploitation of ideas, inventions and know-how arising from its own research projects. Units may offer their research ideas to the Collaborative Centre which then decides whether the idea merits further research to investigate or promote its commercial capability. The Collaborative Centre has been very active in seeking partners abroad as well as in Britain. Fifteen out of its 27 current projects involve overseas industrial partners. An example of this is the agency agreement with the Sumitomo Corporation in Japan. Through this agreement, the Centre has successfully negotiated two projects and a licence with Japanese companies, and is currently in discussion with two others.

The Council also operates a co-operative grant scheme to universities; this allows universities to apply to the Council for support to develop a project with an industrial partner.

Recently a system of collaborative studentships has been set up. These are studentships leading to a PhD which are jointly supervised by an academic from a university, polytechnic or an MRC unit and by an employee of industry or a public sector laboratory. For the academic year beginning October 1990, 60 such awards have been offered.

MRC also participates in the LINK programme, together with other Research Councils and DTI. After a slow start this scheme is now producing some worthwhile collaborations which should result in effective technology transfer. A relationship is also developing with CEST, but it is as yet too soon to say what role this organisation might have in assisting in technology transfer in MRC's field of interest.

In broad terms MRC considers that the in-house framework established for exploitation of inventions and know-how is adequate, and, as royalty income has increased, it has been possible to expand activities and undertake large-scale ventures on its own behalf. The Council has, for instance, licensed the "reshaped antibody" technology developed by Dr G Winter and his team at the Laboratory of Molecular Biology to companies in the UK, Europe, the USA and Japan, and has already earned over £0.5 million from licence fees alone. It has also made a major effort to ensure that wide-ranging interactions with industry are established under the AIDS Directed Programme, placing contracts with companies for the supply of key research reagents, setting up collaborative research projects with companies and, when appropriate, arranging for the patenting and licensing of advances made under the Programme.

In summary therefore, the MRC is actively pursuing opportunities for collaboration with industry and exploitation of MRC intellectual property and know-how.

There remain some concerns:

1. The difficulty of recruiting personnel with suitable experience to manage exploitation within the constraints of normal public sector salary structures.
2. UK industry is sometimes slow to respond to the possibility of taking up opportunities for collaboration and exploitation in comparison to US, Japanese and European companies. An academic sector which is hard pressed financially cannot afford to lose potential income simply to ensure take-up within the UK.
3. As commercial awareness and expertise increase within the academic sector companies must learn to appreciate that academic institutions are more likely to charge full economic cost for collaborative research and/or seek better deals on intellectual property rights arising from the research.

Letter from Professor J S Metcalfe

I am responding to your letter of the 13 March concerning the study on Innovation and Manufacturing Industry, which their Lordships are conducting. Frankly, I have little to say to the rather general questions your letter poses, each one is itself worthy of a major study. However, you may like to know that ACOST will shortly be publishing a study on "Barriers to Growth in SMEs". This dealt with questions of finance, innovation, intellectual property and strategic management training. It would be impossible for me to give full flavour to its conclusions, but four of the main points are as follows:

(i) The venture capital industry is not making a strong contribution to the finance of small, technology based firms. A major reason for this is not shortage of capital but shortage of able managers, both within venture capital companies and in the companies they invest in.

(ii) Current government innovation support policy, with its emphasis on collaboration and "far from market", scientific development, is contrary to the needs of smaller firms. This policy fails to address the risk factor in innovation which is a major consideration, limiting the ability of smaller firms to innovate.

(iii) Management training can play a much larger role in overcoming growth problems in smaller firms, but it will require new delivery mechanisms to do so.

(iv) Government support policies should involve allocation by competitive mechanisms, not allocation by eligibility criteria, in social security fashion. Firms compete in the market place, they should compete for government support too.

One or two more general points may help your deliberations. First, the aim of policy should be to raise the creativity of the national innovation system. It should not be overburdened with narrow concerns of efficiency in resource allocation. Ultimately, the aim must be to raise the rate of business experimentation around new technology, and this is primarily a question of infrastructure and organisation and only secondarily a question of the R&D spend [Indeed, R&D is such a heterogeneous collection of activities, that one has great difficulty understanding the statistics. Not all research projects are equally productive, spending on one "genius" may be worth the spend on one hundred research mortals!]. On this institutional question, I would emphasise three points:

(i) Links between companies and the science and technology base, recognizing that technology is more important than pure science in this context. Science is concerned with thoughts, technology is concerned with actions and in the UK we do not have the balance of emphasis right.

(ii) Links between companies through customer/supplier interrelationships. There is increasing evidence that these links have a major influence in the innovation process and that interaction with intelligent customers is particularly stimulating. Professor Rothwell will be able to guide you with authority on these matters.

(iii) Many experiments will fail and it is important that failure is seen as an integral part of the learning process which supports innovation. It is very much a matter of trial and error and diversity and plurality approach is far more important than picking winners and identifying national champions. Failure must be accommodated and not be seen as a waste of resources.

Remember, also, that the UK is a small country in world terms, so that the greater proportion of leading edge technology is being developed externally. Your emphasis on technology transfer is therefore highly appropriate.

If you wish to raise any more specific questions. I will do my best to help you.

J S METCALFE
Professor of Economics
23 *April* 1990

Memorandum by the Ministry of Agriculture, Fisheries and Food

MAIN POINTS

Structure of the food and drink industries in the UK—diverse sector. Many small enterprises but a few very large businesses dominate market. Changing consumer tastes mean new demands.

Public sector investment in food technology research—MAFF spent £8.1 million in 1989 on external food tech research. Split between AFRC, FRA's and Universities. FRA's bridge gap between basic research and industry.

Technological investment by industry—Varies across sector. Proportionately lower than manufacturing industries in general. Most industrial sector work on short-term development.

Impact of technologists

Technological skills

Stimulation of technical innovation—Link programme in the Food Processing Sciences. Possible Link programme on Agro-Food quality.

Impact of regulation on innovation—important to maintain public confidence in safety of food.

1. The Ministry is grateful for the opportunity to submit evidence to the Select Committee. Responsibility within Government for manufacturing industry in general lies primarily with DTI. MAFF however has lead responsibility for the food and drink manufacturing industries. These industries contribute some 10 per cent to the value added by UK manufacturing industry.

2. As background to the Select Committee's enquiry it may be helpful to provide some general information on the structure of the food and drink industries in the United Kingdom.

STRUCTURAL FACTORS

Manufacturing Sector

3. The food and drink manufacturing industries currently have sales of around £50 billion and employ over 550,000 people, just under 10 per cent of the total workforce in UK manufacturing. In 1987 there were over 9,000 enterprises, excluding the very small businesses, but with 20 enterprises accounting for about one-third of output. It is a diverse sector ranging from simple low value added processes such as livestock slaughtering to more complex high value added products such as ready meals.

Food Retailing and Catering

4. The UK food retailing sector has sales of around £60 billion and employs over 1 million full- and part-time staff (including self-employed). In recent years, there has been a considerable increase in concentration with the number of businesses falling from 142,000 in 1971 to less than 75,000 today and with the 10 largest food retailers accounting for over 50 per cent of all food sales. This has placed pressure on food manufacturers to develop new products. Catering remains an industry dominated by small units. Recent estimates suggest that there are over 150,000 outlets and a total turnover in the region of £20 billion. Changing consumer tastes and changing technology in catering have placed new demands on food manufacturing in an increasingly sophisticated food chain.

PUBLIC SECTOR INVESTMENT IN FOOD TECHNOLOGY RESEARCH

5. In 1989 the total Government spend on food research was £30.9 million. Of this MAFF spent a total of £8.1 million on food technology through external commissions distributed between the Agricultural and Food Research Council (£6.0 million), the Food Research Associations (£1.8 million) and the Universities and other laboratories (£0.3 million). This provides an important part of the underpinning science base for industry to use for its own introduction, and with the removal of near market support, it is being progressively undertaken through LINK programmes (see paras 15-17).

6. MAFF has traditionally relied on the Food Research Associations (FRAs) to provide the bridge between the basic research undertaken in AFRC Institutes and Universities and industry. The membership base of the FRAs is well suited to transferring technological innovation to small- and medium-sized enterprises. However, there is, in the Ministry's view, a need to examine just how effective they are in practice at effecting such transfers. We will be following this up with the FRAs.

TECHNOLOGICAL INVESTMENT BY INDUSTRY

7. The industrial investment in research varies considerably across the sector. A few large companies have in-house research facilities which compare well with the public sector and in selected areas are probably in advance of work undertaken in public sector laboratories. Their scientists interact closely with the public sector research base. The majority of the remaining companies focus their investment on product development and quality control. Their primary contact with scientific innovation is through the FRAs. Many smaller food companies undertake virtually no research and little product or process development.

8. According to the Food and Drink Federation, UK food and drink industries invested in excess of £100 million per annum in R&D, some 90 per cent of which is in-house activity. The majority of the industrial sector expenditure is on short-term development work.

9. The retailing sector have argued that their suppliers have the primary responsibility to invest in research. It is not known what proportion of their turnover is invested in R&D but it is thought to be low. However, recently, the major retailers have increased their efforts in quality control, as a response to the requirements for them to show due diligence in the safety and quality of foods which they sell, and also have entered into joint research activities, primarily through the LINK scheme.

10. Studies undertaken by ACARD (1982), NEDO (1985), the Technical Change Centre (1985) and the Priorities Board (1987), have all concluded that the food manufacturing sector is investing a low proportion of its profit in longer-term R&D compared with the manufacturing sector in general. The transfer of the results of public sector R&D to the private sector was highlighted as an issue which needed improvement. MAFF has addressed this issue with one of the FRAs through a pilot scheme and is considering a further scheme, as referred to in paragraph 6.

11. Industry have in the past argued that the low return achieved on investment has limited its potential to invest more in longer-term research initiatives.

IMPACT OF TECHNOLOGISTS

12. We do not know the extent to which technologists influence investment decisions in the industry through representation on the Corporate Board of Directors.

TECHNOLOGICAL SKILLS

13. The food industry recruits a wide range of basic and applied scientists. The training given to food science graduates in the UK fits them primarily for general management and production in the food industry. Where the industry has an in-house research facility, then this is predominantly staffed by graduates in the basic sciences. The industry has indicated a concern as to the quality and availability of scientists from other disciplines. We do not, however, have the information with which to judge the seriousness of the problem and how it might impact on the innovativeness of the industry.

STIMULATION OF TECHNICAL INNOVATION

14. MAFF has worked closely with the DTI in a range of schemes which have operated to stimulate the take-up of innovation by industry.

15. At present MAFF and the DTI are jointly investing some £3.5 million each over five years in a LINK Programme in the Food Processing Sciences. The principal objectives of the scheme are:

- To encourage collaborative R&D that will strengthen the industry's technical base in bioscience;
- To encourage strategic developments in new processes, biotechnology, food safety and process modelling and control.

16. Some £2 million of the programme's resources are already committed with a significant number of projects close to approval. This makes this programme one of the most successful of all the LINK Programmes.

17. MAFF is presently preparing proposals for a further LINK Programme on Agro-Food Quality. If agreed, this programme would commit some £5 million of Government funds over a period of five years. The principal objectives of this programme would be to:

- Define more accurately the primary quality characteristics of raw materials which will improve the acceptability of these materials to end users.
- Generate more precise definitions of food quality through the stimulation of pre-competitive research in novel techniques, measure and define quality attributes including the genetic basis defining these attributes.

18. MAFF support for food technology in the FRAs is increasingly conditional on the provision of matched industrial support in underpinning research initiatives. Industry is directly involved in their management.

19. Further initiatives for stimulating technical innovation in industry are being considered, e.g., involvement in the SERC's Teaching Company Scheme.

INPUT OF REGULATION ON INNOVATION

20. In response to consumers' concerns, Government and the EC are putting in place a series of regulatory controls which necessarily impose some additional burdens on industry. Yet where, for example, regulatory controls do not yet exist (e.g., in the control of novel foods based on genetically modified organisms) it is significant that industry has taken a very cautious approach. It is also noteworthy that there can be public pressures against innovation, which discourage industrial investment, where regulation is lacking or is seen as inadequate. Regulation therefore has an important role to play in maintaining public confidence in the safety of food and can be an essential part of the infra-structure necessary for further investment in innovation. The Department sees as one of its aims the development of greater public awareness of the effectiveness of its regulatory activities in the food safety and related areas. This should in turn improve the climate for further innovation by the industry.

21. Innovation in the food industry is influenced by the regulatory regime applied. A balance has to be drawn between the objectives of safety, quality, novelty, availability and convenience. The Government seeks to ensure that the regulatory regime applied maximises public safety without unnecessarily inhibiting the scope for innovation.

May 1990

Memorandum by MSF

MSF has 650,000 members spread across most sectors of industry and it is the union with the largest membership amongst professional, scientific and technical staff in UK manufacturing industry.

We believe that greatly increased levels of research and innovation, investment and training are vital if the continuing decline in UK manufacturing industry relation is to be halted and reversed. This was the theme lying behind the publication of our pamphlet "Making our Future—Manufacturing in the 1990's" published earlier this year in conjunction with the TGWU.

Company Attitudes

Short-termism has now been diagnosed as the real "British disease" which is undermining manufacturing industry. Its symptoms are of course the emphasis on short-term profits and share prices, the payment of excessive dividends and takeover fever, which leads to a preoccupation with growth through acquisition at home and overseas. It manifests itself in company behaviour with the effect that companies lack interest in or awareness of, anything which does not offer a high return in a short period of time and their ability to progress an interest is limited by excessive borrowings at high interest rates.

In UK industry it is the accountant and not the engineer who is in control. Whether it is GEC or Hanson the pre-occupation is always with financial controls and rates of return. A non-production culture develops which is disposed to seek established or protected markets abandoning others, and to supplement unspectacular results by dealing in assets.

This sort of culture leads directly to a position where engineers have low pay and status and where training is regarded as a cost rather than an investment.

City Attitudes

The report of the DTI's Innovation Advisory Board on "Innovation: City Attitudes and Practice" provides a damning summary of companies neglect of innovatory activity and the preference for maintaining dividends. It then highlights the lack of appreciation of innovatory activity by the City and makes a series of recommendations as to how this might be remedied. We would support the direction of these changes but think that stronger action is needed, in particular to deter short-term share dealings by institutions.

Government Policy

We believe it is the responsibility of the Government to try and promote "long-termism", which manufacturing industry so conspicuously overlooks. This requires action which extends across the whole field of industrial policy, e.g., into measures which aim to discourage takeovers (a copy of our submission to the Trade and Industry Committee Inquiry into Takeovers and Mergers is attached).

An overhaul of Corporation Tax designed to provide incentives to investment and R&D and to discourage dividend distributions is much needed. The support of institutional shareholders needs to be won for the retention of profits within companies and companies need to build stronger links with their shareholders perhaps via supervisory boards or institutional shareholders committees. Enforcing disclosure of audited information about R&D spending might help matters by enabling peer group companies to be made.

Consideration should be given to the establishment of a National Research Agency or Directorate. This would aim to stimulate R&D and innovation activity by entering into partnership agreements with companies. Such an Agency would aim to collaborate with industry and would appoint its own staff and set a lead in establishing best practice employment conditions.

Technology Transfer

Technology transfer mechanisms in the UK compares poorly with those of our major industrial competitors. This is clearly demonstrated though perhaps understated in the conclusions of the recent NEDC report on "Technology Transfer Mechanisms". What it did say was that "in the FRG, Japan and France central government financial commitment towards the establishment of technology transfer and diffusion mechanisms appears to be greater than in the UK". A similar conclusion was drawn in relation to regional authorities establishing local technology transfer mechanisms. In our view the rather fragmentary mechanisms in the UK are worlds apart from the much more comprehensive set-up in Germany.

Patents

It is important that patents legislation is kept abreast of the position in other countries. We therefore welcome EC Commission's proposals to extend the effective life of patents in the Community by the use of special certificates extending patent protection from the time a product actually comes on the market. In pharmaceuticals this is particularly crucial because of the time it takes to get new drugs on to the market.

Pharmaceuticals has been more successful, especially in innovation, than other UK industries. It is interesting to note that the Innovation Advisory Board Report showed that City analysts in this sector were predominantly science graduates capable of understanding the industry's technology which contrasted with other sectors like electronics.

Environmental Considerations

Environmental issues facing the UK and the world will throw up particular challenges for innovation and R&D in manufacturing industry. Companies will need to alter their operations, invest in new product development, identify new markets and clean up production processes. The Government should be doing much more to encourage innovation in this area.

When it comes to adopting clean technologies there is evidence that UK is lagging behind. Not a single UK firm was present at the prestigious Envibrno Trades Fair held in October 1990 at Brno, Czeckoslovakia which provided a showcase for companies active in the environment protection field.

The important role of government is in terms of making early adjustments in the regulatory environment in the UK which encourage industry to lead rather than lag in adopting clean technologies and so avoid losing out in international markets to more progressive competitors. A prime example here would be the motor industry and regulations on exhaust emissions.

Energy is another area where Government policy has discouraged innovation. Over-reliance on the nuclear option has been at the expense of not supporting research into renewables, including the sorry tale of "mistakes" in costings which cost us a lead in the development of wave power (the Salter's Duck project). The current pre-occupation with privatisation means that projects such as the Grimethorpe pressurised fluidised bed combustion facility are being developed so slowly as to mean they will make little contribution to the UK meeting sulphur dioxide limits even by 1992 (see House of Commons Energy Committee "The Flue Gas Desulphurisation Programme, June 1990).

EC Support for Innovation

The UK does not benefit sufficiently from EC support for innovation in some areas, though generally the public sector and large companies do not do badly out of programmes.

Failure to obtain more benefit reflects partly on the nature of the programmes. This is because they are concentrated too much on pre-competitive research and too little on innovation. We would like to see the balance shifted, e.g., by expansion of the SPRINT (Strategic Programme for Innovation and Technology Transfer) and VALUE (Valorisation and Utilisation for Europe Programmes).

In certain areas failure to benefit is our own fault. Most conspicuous is our absence from the JESSI (Joint European Submics on Silicon Initiative) programme, the largest single EC research project, because we have opted out of bulk chip production.

There is a more general problem when it comes down to SME's (small- and medium-sized enterprises) who aren't getting involved. A further area that needs looking at is involvement of companies in the regions and here something definitely could be done as EC Regional Policy money could be made available for equipment and training preparatory to participation.

Ironically while UK companies are keen to expand overseas they are not very good at collaboration. In 1989 only 12 of 89 Eureka programmes had UK partners involved.

The Effects of Skill Shortages

Availability of skilled workers is a key factor influencing the decision to undertake innovation.

The problem of skill shortages is well recognised and documented but the impact on innovatory activity is especially severe and wider ranging. It has been estimated, for example, that to raise the number of scientists and engineers working in industrial research and development to French or German levels we need to increase the numbers in this country by 50 per cent. But it is evident that skilled workers in such numbers are simply not available which can only influence companies attitudes to innovatory activity.

If the fundamental area of Information Technology is considered then you come up against the "IT productivity paradox". This is based on the finding that companies find productivity gains from IT are rarely as much as originally expected which makes it difficult to justify further innovatory activity in this area. Lack of skilled staff is the most popular explanation for it.

In the closely related area of corporate telecommunications skill shortages again are preventing innovation. As we move toward a more information based economy telecommunications becomes less a resource and more a competitive weapon. Companies are looking to plan, design, implement and operate networks on a local, national and international basis. Yet in a recent survey (by Communications Week International, May 1989) the most important barriers to achieving this objective were inability to get staff, inability to educate users, high training costs and poor corporate communications strategies. All of these are manpower related.

Skill shortages are not of course confined to the UK. Availability of skill will naturally be a powerful influence both on the location of investment and on its research and innovation content.

Defence Diversification

In October 1990 MSF published "The New Industrial Challenge—The need for Defence Diversification", in partnership with the IPMS and TGWU. This document endorsed the ACOST report on "Defence R&D: A National Resource".

In the changed Europe of the 1990's the MOD should focus its R&D spending on enabling technologies, develop evaluation systems to assess the degree of cross fertilisation achieved and, as a minimum, give research establishments the incentives, and Defence Technology Enterprises the resources, to encourage greater spin-off. The programmes to assist suppliers to diversify should be co-ordinated by a diversification body. After years of encouraging suppliers to rely on the MOD, that is the least the Government can do.

The success of the new Defence Research Agency in attracting work from the private sector is important given the Government's explicit policy of cutting defence research expenditure. Losses of skilled personnel will hit just those establishments which encourage spin-offs.

We believe there are very considerable opportunities for defence companies to diversity into environmental technology, space and communications, consumer goods and transport, etc. The defence companies need to establish "Civil Development Centres". These would incorporate knowledge and experience gained from their non-military divisions, their own technological R&D facilities and expert sales and marketing terms. In general managements need to be infused with a greater awareness of commercial possibilities.

We support the Labour Party proposal for a Defence Diversification Agency but would stress that to be effective it would have to be properly funded and employ expert advisors, including engineers, scientists and marketing specialists in the mainstream of industrial policy.

MSF
7 November 1990

Memorandum by Dr R P Oakey, Heriot Watt University

HIGH TECHNOLOGY SMALL FIRMS: THEIR POTENTIAL FOR RAPID INDUSTRIAL GROWTH

SUMMARY

This paper examines the growth performance of British high technology small firms throughout the 1980's. The analysis is divided between a consideration of employment growth, and the extent to which firms rely on self-financed growth in the electronics, scientific instruments and biotechnology sectors. It is noted that the observed growth, both in individual firms and in aggregate, has been unimpressive. The paper concludes by arguing for a more pro-active government approach to the encouragement of high technology small firms. This approach is based on the assertion that a decade of free-market micro- and macro-economic policy has inhibited expansion in new sectors of industry, where industrial expansion and employment growth is *potentially* of great significance.

1. INTRODUCTION

Concern for the foundation and growth of small firms in general, and high technology small firms in particular, has been a major feature of government industrial policy throughout the 1980s. The widespread enthusiasm for entrepreneurship across all political parties, and the growing interest of academics in the small firm as a vehicle for industrial growth in the early part of the decade, helped to produce a consensus of opinion on the need to encourage small firm expansion as means of reducing unemployment caused by the failure of mainly large enterprises. Much of this small firm interest was stimulated by the work of David Birch (1979), which claimed that substantial employment growth was provided by new small firms in the United States. Although many of the findings of this work were subsequently heavily questioned regarding their accuracy in general, and their relevance to Britain in particular, the message that new small firms were a substantial cure for growing unemployment in British manufacturing industry helped to increase the growing political interest in small firms as an uncomplicated means of industrial revival, and to prompt the adoption of small firm oriented industrial policies. However, as considered academic results on the employment role of small firms in the 1980s began to emerge, many reservations were expressed on the ability of small firms to produce rapid output and/or employment growth (Storey 1982, while the aggregate contribution to employment of small firms in any local economy was judged to be medium- to long-term in nature. (Fothergill and Gudgin 1982).

The role of high technology small firms was crucial to this general debate on the employment potential of small firms since evidence, again mainly from the United States, had indicated that the number of fast-growing small firms was particularly high in the new technology-based industries, mainly founded on microprocessor technology (Morse 1976; Rotherwell and Zegveld 1982). Moreover, early evidence on the birth and growth of the biotechnology industry in the late 1970s appeared to suggest that small firms were similarly providing much of the impetus for innovation and growth in this emerging sector (Kenney 1987). The perceived need to focus on the new high technology sectors as a means of maximising new small firm growth was articulated by the growth of the "Science Park Movement" throughout the 1980s. In particular, largely unsubstantiated evidence from the United States on technical information interactions between clusters of high technology industrial growth and universities (e.g., Silicon Valley—Stanford University and Route 128—Massachusetts Institute of Technology [MIT]), together with revenue shortages, caused many British universities to establish science parks to provide a geographical focus for policies directed at new high technology firm formation through entrepreneurship in high technology small firms.

In retrospect, it is fair to state that most of these enthusiasms and subsequent policy initiatives were based on highly questionable assumptions of the employment potential of small firms in general, and high technology small firms in particular. A common thread running through all the above discussion is the persistent observation that most of the justification for a belief in the growth potential of small firms emanates from the United States. However, the initiation of policies in the United Kingdom on evidence mainly derived from the United States is a strategy that contains two major flaws. First, much of the assumed causality may be bogus. For example, the "link" between United States technical universities and new high technology firms has been argued to more likely stem from entrepreneurial "spin off" than regular technical information exchange. Certainly, recent empirical research found little evidence of such interactions between universities and new high technology small firms, neither in Britain or the United States (Oakey 1984; Oakey *et al* 1988). Moreover, if the role of the university is one of "incubation", the advocation of technical interaction as a major attraction of British science parks might be irrelevant (Trinity College Cambridge 1983), while entrepreneurial "spin-off" from British universities is generally poor (Roberts and Feber 1984) (Oakey 1985). Second, the noted technology-based small firms growth in the United States might not be relevant to the British case for a host of macro-economic and political factors that differ between the two nations (e.g., very high levels of defence spending, attitudes towards wealth creation, etc.). Indeed, most of the observed small firm growth in the United States took place in the 1960s and 1970s, a period in which similar British growth was only notable through its absence (Oakey and Rothwell 1985).

There are two major means by which small firms can contribute to the employment growth of a nation or constituent region. First, there is the large employment gains that can occur when *individual* small firms make the transition from small to large size. Indeed, this is a major way in which small American firms contributed to employment growth in the United States manufacturing industry in the 1970s. The growth of small firms in the electronics industry, founded on initial semiconductor technology, is well documented (Freeman 1982), while the "splintering" of new small firms from large firms that had been small firms in the past, in agglomerated industrial areas such as Silicon Valley, is also clearly recorded (Mason 1979). In this context, the failure of Britain to produce new large electronics firms of the stature of Intel, Mostec and Texas Instruments, is a measure of this international growth discrepancy in the electronics industry. Indeed, with the exception of Amstrad, the well known "false dawns" provided by Acorn Computers, Sinclair and Inmos, indicate that the emergence of an *independently owned* new generation of British high volume high technology electronics manufacturer remains elusive. The inability, or unwillingness, of established British large scale electronics manufacturers to compete substantially in these lucrative businesses, ensures that the American and Japanese remain free to compete for this substantial market.

It is possibly because there have been no singular success story of individual small firms achieving large size that government agencies have attempted to find evidence of a new entrepreneurial environment through an emphasis on quantity of firms, rather than quality. In particular, in the early 1980s, there were a series of government and academic studies of new firm formation levels (Ganguly 1982; Storey 1982; Fothergill and Gudgin 1982), in an environment where politicians argued that individual entrepreneurship would be a major means of combatting high unemployment through new firm formation. The establishment of enterprise zones in which operating costs are reduced, together with a longer term aim of reducing personal taxation as a stimulus towards greater enterprise, was part of a general philosophy aimed at encouraging enterprise at the beginning of the decade. However, it is ironic that the recent achievement of a 25 per cent level of income tax appears to have contributed to a consumer boom rather than encouraged investment in industry. Certainly, the "reduce taxation to encourage enterprise and investment" argument is now rarely advocated as a *current* solution to growing inflation and balance of payments difficulties.

However, with regard to high technology small firms, the "new firm formations" approach to defining success has endured throughout the period. Clearly, there is a degree of superficial logic in the assumption that national and regional high technology new firm formation rates are a measure of success (Little 1977), and it is clear that spatially different rates of new firm formation are means of defining concentrations of high technology industrial production (Segal Quince and Partners 1985; Keeble and Kelly 1988). However, if the reader delves beyond this crude new enterprise count, and divides the number of formations into the total number of jobs created it is clear that, in the majority of cases, most new firms do not contribute substantially to employment. For example, in the study by Keeble and Kelly, while there were 61 computer firms founded between 1975 and 1984 within Greater London, their total employment was 1,340 workers, producing an average of 22 workers per firm (Keeble and Kelly 1988). Although these authors indicate that there has been a greater proportionate increase of new firm formations in rural rather than urban locations, the average size of firm at 28 workers from a total national employment level of 8,931 employees provided by new firms in the British computer industry, indicates that the number of firm formations often diverts attention from the generally meagre level of *post-formation* employment growth. It is certainly clear that such small sectoral levels of employment increase from new firms in such a key high technology sector are unlikely to substantially ease unemployment problems at the national or regional levels.

2. Evidence on employment growth and financial self-sufficiency in high technology small firms

The above general comments on the post-formation performance of high technology small firms have been stimulated by ten years work on the problems of innovation and growth in new and established firms in three technologically diverse high technology industrial sectors. Although a wide range of data collected on this subject indicate the struggle of most high technology small firms in their attempt to survive and grow, two key indicators of this fight for survival are considered here to illustrate the problems and achievements of such firms. First, employment levels in these industries will be presented to indicate the slow growth that is generally achieved. Second, consideration will be given to the extent to which firms rely on internal profits as a main capital investment source, as a risk-averse means of matching investment to that which is affordable from ploughed back profits. This initial evidence on employment makes it clear that the few firms reliant on external capital as a main source of investment funding, generally are not using external capital to achieve rapid growth, since rapid growth rarely occurs.

2.1 *Employment change*

The first data presented on employment growth is taken from a study of small independent instruments and electronics firms employing less than 200 workers in Britain (i.e., South East England and Scotland), and Silicon Valley California, in the United States in 1981-82 (Oakey 1984). In this period, Silicon Valley remained economically buoyant and Table 1, which compares employment growth in new firms founded in the five year period prior to the study, indicates that British firms produced an average of 17 workers per firm, compared with 57 workers per firm in Silicon Valley. These data from randomly sampled small firms in Britain and the United States tend to support the above assertions on the danger of assuming that phenomena that exist in America will be replicated in Britain. Indeed, the more impressive average performance in the United States instance is mainly caused by three particular firms that grew from formation to employ 125, 150 and 200 workers within five years. In comparison, the fastest growing British firm employed 53 employees by the time of interview. Thus, the assertion that Britain does not produce the rapid growing high technology small firms, that are realistic candidates for fast transition into large size, appears to receive some support from these results.

The second set of evidence on employment change in high technology small firms is taken from a time series study of new and established firms (including those in Table 1) in Britain (South-East England and Scotland) and Silicon Valley in the United States (Table 2). The survey covered the period 1981-85 in Britain and 1982-86 in the United States. From the 114 British firms that were trading in 1981, an additional 354 net jobs had been created by 1985, while the 60 American firms created 338 net new jobs between 1982 and 1986. The 43 remaining American firms in 1986, produced 1,193 new jobs at an average of 28 jobs per firm, compared with an average of 11 new jobs per surviving firm in the 88 enterprises comprising the British 1985 survey population. However, the American performance was marred by a particularly large number of jobs lost through closure as a deep recession hit the United States semiconductor industry in 1985. The overall impression created by these data is that, although the American performance is superior to that of Britain, neither the net aggregate jobs created, nor average jobs gained in either Britain or the United States, had any substantial impact on employment. While these figures relate to samples and not total populations in Britain and the United States, the above rate of employment increase suggests that overall job growth in high technology small manufacturing firms cannot compensate for massive job losses in other more traditional industrial sectors. In particular, the picture in Britain appears one of slow aggregate and individual growth in this type of small firm. Indeed, these results conform to the above information on the related computer industry (Keeble and Kelly 1988).

TABLE 1.

Jobs created in firms less than five years old by region in British and United States instruments and electronics firms.

	Britain	United States of America
Number of firms	19	14
Total jobs	329	796
Average jobs per firm	17	57

Source: Oakey 1984.

TABLE 2

Precise job gains, losses and net change in survey firms (excluding refusals to interview 1985-86) in British and United States instruments and electronics firms.

	Britain	United States of America
Job gains	+990	+1,193
Job losses	−384	−236
Job change	+606	+957
Closure job losses	−252	−619
Net job change	+354	+338

Source: Oakey, *et al* 1988.

This section on employment change is concluded with the presentation of evidence from the British biotechnology industry on firm growth this new sector. These data are taken from a recent study of new firms in the British biotechnology industry (Oakey et al 1990). The data included in Table 3 was collected in 1988, and represent *all* the identifiable United Kingdom firms producing biotechnology products or services in the year of survey. The critical part of the table with regard to modern high technology biotechnology production is the column that deals with firms founded since 1975. Although the 71 firms in this grouping include a number of firms founded as subsidiaries of large chemical and pharmaceuticals firms (with all the resource implications this implies), only 10 per cent of the new firms had exceeded 100 employees during the twelve-year survey period, while 73 per cent of these firms employed less than 50 workers. Indeed, the very small minority of 43 firms that were founded as totally independent firms between 1976 and 1988 produced only one firm that exceeded the 100 employee size band over the twelve-year study period, (i.e., Celltech).

Both the low level of independent new firm formation in this industry and the slow rate of subsequent growth suggest that the biotechnology industry is currently not a significant source of small firm employment growth.

TABLE 3

United Kingdom biotechnology firm employment size by age

	Pre-1945		1945-74		Post-1974	
	n	%	*n*	%	*n*	%
1-19	1	(4.3)	7	(15.2)	36	(50.7)
20-49	1	(4.3)	7	(15.2)	16	(22.5)
50-99	2	(8.7)	8	(17.4)	12	(16.9)
100-199	3	(13.0)	10	(21.7)	5	(7.0)
200+	16	(69.6)	14	(30.4)	2	(2.8)
Total	23	(100.0)	46	(100.0)	71	(100.0)

Chi-square = 64.436 p = 0.0001
Source: Oakey *et al* 1990

Taking all these data on high technology small firms together, it is clear that a more realistic approach to their growth potential needs to be adopted, and in particular, the biotechnology industry clearly indicates that a high level of technical sophistication and R&D spending *does not* imply that rapid growth is assured (Oakey *et al* 1990). These comments on the employment potential of high technology small firms are given further support by related evidence on the ability of firms to generate self sustained profits.

2.2 *The desire and ability to generate self sustaining profits*

The generally slow employment growth apparent in the above passages owes much to the basic approach of a majority of high technology small firm founders in which a risk averse approach is adopted to growth where expansion is tailored to the level of self generated profit that can be generated in a given year. This strategy avoids the danger of the external involvement that frequently accompanies loans or deeper equity stake involvement. This conservatism, together with the frequently onerous conditions placed on external financial investment, ensures that external funding is kept to a minimum. This approach is widespread, both in Britain and the United States, although the three fast-growing firms mentioned in connection with Table 1 were all supported by external venture capital firms. Following the sequence of presentation used for employment data, Table 4, which initially indicates the proportion of British and United States high technology small firms relying on profits as a main source of capital investment in early work on instruments and electronic firms in 1981-82 (Oakey 1984), clearly indicates that almost exactly three-quarters of firms in both countries relied on profits as a main investment source. Significantly, although venture capital involvement was higher in the United States, it remained in a clear minority at 15 per cent. Although it might be argued that this predominantly risk averse strategy is less than optimal, the approach ensures continuity of control for the firm founders, and importantly in view of subsequent evidence on the biotechnology sector, implies that the business activities of the firms surveyed allows modest profits on which subsequent internal investment is based.

TABLE 4

Main source of investment finance, 1981-82 and 1985-86, by region in instruments and electronics firms

	Britain				United States of America				Total			
	1981-82		1985-86		1981-82		1985-86		1981-82		1985-86	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Profits	84	(73.7)	60	(69.0)	45	(75.0)	35	(81.4)	129	(74.1)	95	(73.1)
Local bank	18	(15.8)	10	(11.5)	6	(10.0)	2	(4.7)	24	(13.8)	12	(9.2)
Venture capital	3	(2.6)	2	(2.3)	9	(15.0)	0	(0.0)	12	(6.9)	2	(1.5)
Other	9	(7.9)	15	(17.2)	0	(0.0)	6	(14.0)	9	(5.2)	21	(16.2)
Total	114	(100.0)	87	(100.0)	60	(100.0)	43	(100.0)	174	(100.0)	130	(100.0)

Source: Oakey *et al* 1988

The later time series study of the firms that remained in 1985-86 continued to confirm the importance of self generated profits as the main source of capital in survey firms. This second set of figures in Table 4 confirms a strong reliance on internal profits in both Britain and the United States, with the overall total of firms relying on internal profits as a main source standing at 74 per cent for the first period and 73 per cent in the latter survey. The sharp decline in venture capital access in the re-visit survey for the United States firms was surprising, but probably reflected the problems with the semiconductor industry mentioned above with respect to Silicon Valley.

A final set of data in this sequence of information on the source of investment capital is again derived from the study of new biotechnology firms in the United Kingdom. Table 5 is of particular interest since it offers the opportunity to make a direct comparison between the instruments and electronics industries, and the emerging biotechnology sector. Although it should be noted that the biotechnology firms were *all* less than ten years old, with less time to build up internal profits when compared the mixture of new and established instruments and electronics firms, reliance on internal profits in this industry is exceptionally low. Only 23 per cent of the 43 new biotechnology firms were able to rely on self generated profits as a main capital investment source. In these firms, there was a mixture of external funding sources, led by a 23 per cent level of major capital investment sourcing provided by venture capital. While it might be argued that the low level of internal profits as a main capital investment source could be explained by external investment fueling rapid expansion of the firms concerned in a positive manner, there is little evidence of this phenomenon from the employment data above, or other information collected on turnover (Oakey et al 1990). It seems more likely that the external investment capital involvement in the biotechnology case takes the form of "patient money", invested in the hope that products with unexpectedly long lead times will eventually produce sustainable profits for the assisted firm.

TABLE 5

Major source of investment capital during the last five years in United Kingdom biotechnology firms by the percentage of equity held by bodies external to the firm

	Percentage of equity held externally							
	0		1-50		51-100		Total	
	n	%	*n*	%	*n*	%	*n*	%
Self-generated profits	10	(58.8)	1	(11.1)	0	(0.0)	11	(25.6)
Venture capital	0	(0.0)	4	(44.4)	6	(35.3)	10	(23.3)
Equity	1	(5.9)	1	(11.1)	5	(29.4)	7	(16.3)
Local bank	2	(11.8)	2	(22.2)	1	(5.9)	5	(11.6)
Personal finance	3	(17.6)	0	(0.0)	0	(0.0)	3	(7.0)
Group profits	0	(0.0)	0	(0.0)	3	(17.6)	3	(7.0)
BES	0	(0.0)	1	(11.1)	1	(5.9)	2	(4.7)
Other	1	(5.9)	0	(0.0)	1	(5.9)	2	(4.7)
Total	17	(100.0)	9	(100.0)	17	(100.0)	43	(100.0)

Source: Oakey *et al* 1990

This assertion is leant further support by Table 6, which standardises for age of firm, and compares the new firms in the instruments and electronics study (Oakey 1984) with the biotechnology new firms, notwithstanding that the ten-year "new" periods are not concurrent. The "new" firms are divided in Table 6 into "very new" (i.e., less than five years old) and those firms that had been established for between five and 10 years at the time of survey. There are two significant features of Table 6. First, in the less that five-year-old category, almost exactly twice as many instruments and electronics firms were able to quote self generated profits as a main investment source, when compared with their biotechnology counterparts. Second, in the older grouping, while the instruments and electronics firms produced a higher reliance on internal profits as might have been expected, increasing from 55 per cent to 75 per cent, the equivalent biotechnology firms produced a slightly *lower* proportion of firms reliant on internal profits in the later time period. Although there was ample evidence from the overall research that most firms were reluctant to surrender control of the firm to external bodies, a strategy which often involved allowing *small* equity stake holdings by multiple external investors, the high level of external involvement in this sector appeared to stem from an inability to achieve *desired* self sufficiency. Table 6 is valuable since it indicates that the inability to generate substantial profits is *both* a short- and medium-term problem. It is a significant contribution to the argument of this paper that the higher level of external investment in new biotechnology firms has not produced rapid growth, but has preserved the existence of survey firms through periods where profits were either small or absent. If these funding problems are taken together with the overall small absolute number of new biotechnology firms, and their unimpressive employment growth performance, the prognosis for the contribution of new small firms to the growth of the biotechnology industry cannot be optimistic. Indeed, this new firm potential is further reduced by the observation that 12 (28 per cent) of the original 43 independent firms had been absorbed into larger mainly pharmaceuticals and chemical firms by the end of the survey period (Oakey *et al* 1990).

TABLE 6

Percentage of instruments and electronics and biotechnology firms with internal profits as a main source of investment capital

	Instruments and Electronics (1970-80)		Biotechnology (1976-86)	
Age of firm	*n*	%	*n*	%
1 - 5 years	17	55	7	26
6 - 10 years	42	75	4	25

Total respondents:
British and United States Instruments and Electronics firms = 87.
United Kingdom Biotechnology firms = 42.
Source: Instruments and Electronics data, Oakey 1984.
Biotechnology data, Oakey *et al* 1990.

3. Conclusions

While it is clear that high technology small firms play an important role in the innovation performance of new industries, and interact with large firms in complicated chains of production that produce finished goods, their short to medium term contribution to sectoral employment is, at best, moderate. In particular, the aggregate number of jobs created in the above surveys, the average employment size of small firms, and the incidence of individual growth from small firms into large enterprises, are generally meagre contributions to employment, when set against the potential for job gains and losses across all manufacturing industries. Although it is clear that any level of job creation is welcome, the preoccupation with the employment potential of high technology small firms throughout the 1980s might be seen in hindsight to be a distraction from concern for more mature sectors of industry and scales of production where only large firms can compete, and where large numbers of jobs are at stake, (e.g., motor vehicles; aerospace). Probably the enduring disappointment of the 1980s is the inability of the high technology firms founded during this period to produce a "flagship" new firm that grew to large size to lead British production in the electronics, computer or biotechnology sectors. A small number of successful firms of this type would have transformed their sectors by being able to compete at a world level in high volume high technology markets, provide business for smaller supplier firms, and act as an incubator for further new firm spin offs in the future (Oakey 1989). While a number of promising firms remain, in an acquired form, as part of foreign multi national firms, (e.g., Acorn Computers; Inmos), this new subsidiary status does not permit the leadership envisaged by a totally independent British owned firm, especially when control and investment decisions lie overseas.

Both the evidence from the random sample surveys of this paper, and general evidence from the financial press, suggests that the actual performance of British high technology small firms has not matched expectations regarding this type of enterprise. Indeed, what may have been a political ploy of over-emphasising the potential growth of high technology small firms as a diversionary tactic to draw attention away from the problems of larger firms in more traditional sectors has partly caused unrealistic expectations towards the growth potential of these firms. Two major economic features help explain the modest level of employment growth in these firms.

First, the biotechnology example is valuable since both Table 6 and other detailed investigations (Oakey *et al* 1990) clearly indicate that the output and employment growth achieved by this sector have not reached the levels anticipated by many observers of high technology industry at the beginning of the 1980s. The application of basic principles of biotechnology in production have proven more difficult than originally envisaged in many instances, while on other occasions the technically successful development of new biotechnology processes have proven more expensive (or no cheaper) than existing methods. The predicted bonanza of technology-led product innovation and highly lucrative product sales has not been achieved in reality, and the biotechnology industry is proving that high levels of R&D investment are *no guarantee* of world beating product sales. Similarly in the electronics industry where self sustaining profits are more easily achieved, many small firms occupy limited niche markets where, although prices may be relatively high and markets assured, the scope for expansion is limited by a small level of demand, or the need to produce small batch or "one off" levels of production where large scale profits are impossible. The above data confirm that only a small proportion of all new high technology small firms have rapid growth *potential* which may be curtailed by acquisition, or frustrated by the risk averse management behaviour of the firm founders.

Second, and notwithstanding these valid preceding reservations on the limited number of firms with true growth potential, those firms that do possess products that could achieve substantial increases in sales are often introspective in their attitude towards expansion. Although these managers might be accused of a lack of enterprise, perhaps a stronger reason for their conservative behaviour is the generally difficult and hostile business environment which they inhabit, which has remained generally unconducive to growth throughout the 1980s. A fluctuating pound has made both imported inputs to the production processes of high technology small firms, and their exports, a more precarious exercise. Also, generally high interest rates throughout the period, and full or partial recessions, have not encouraged investment in either R&D directed at new product developments, or the purchase of new equipment. The cost of external borrowing and the onerous levels of assets required to secure loans, together with the requirement that substantial amounts of equity should be surrendered in return for investment, risks a loss of control, or possible bankruptcy in the medium term. In such circumstances, both the low level of employment gain and the high degree of reliance on internal profits for expansion (with only biotechnology firms obtaining substantial amounts of external funding in order to survive), suggest that the general business environment in which these firms exist is not conducive to vigorous innovation and growth.

A possible policy response to this difficult environment for expansion is the more proactive assistance of firms throughout the complete innovation cycle from the original programme of R&D, through production, to the marketing of the final product. The basic principle of such an approach would be an attempt to increase the level of innovation and growth that would occur in the "natural" un-assisted environment described above. The more proactive approach might be applicable to break down the natural introspection that develops among firm managements. While greater assistance could be delivered into the firm on a number of themes, current research taking place at Heriot-Watt University, under the direction of the author seeks to test this proactive approach in terms of delivering marketing assistance to high technology small firms. Previous work had discovered that many of these firms were largely reactive to the market for their goods, generally relying on unsolicited demand which clearly does not maximise sales of their output (Oakey *et al* 1988). This assistance with marketing is viewed as an experiment into the cost-benefit of proactive assistance programmes that might be justified if the level of assistance is "paid for" by the additional sales the involvement creates.

In conclusion, it is hoped that the evidence of this paper has indicated that high technology small firms are currently not a major source of innovation and employment growth in the British economy. This paper, by examining the performance of new and established firms in a range of high technology sectors in Britain and the United States, has clearly shown that, in the British case, recent aggregate employment growth has been meagre, while rapid expansion by individual high technology small firms as they make the transition to a large size has been generally absent. An objective examination of these circumstances would logically lead those concerned with the growth of new high technology industries to plan for measures to stimulate growth through policies similar to the proactive experiment described above. However, any evaluation of government policy over the decade of the 1980s must conclude that the general trend in industrial policy towards manufacturing industry at national and regional levels has been a retreat from industrial planning, in favour of a free market approach. The evidence of this paper suggests that such a neglect of high technology small firms by government, together with their macro economic policies (e.g., high interest rates), has created a poor environment for innovation and growth in small firms, while those *few* firms that have shown signs of reaching large size were acquired by foreign competitors in the absence of any British state or private sector support. In the 1990s the nation may eventually regret the missed opportunities for growth that were generally forgone in the previous decade.

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Memorandum by J P O'Connor

CONTENT

This memorandum concerns a proposal for a change in the rate of tax relief applied to expenditure on research and development, such as to increase the co-operation between industry and the academic institutions.

PROPOSAL

It is proposed that the rate of tax relief for expenditure on research and development be increased where:

(1) The company seeking the higher rate of tax relief **CONTRACTS OUT** the research and development to an approved academic institution.

(2) The company seeking the higher rate of tax relief should employ **NOT LESS THAN 50 PEOPLE AND NOT MORE THAN 250 PEOPLE.**

(3) There should be an **UPPER LIMIT** on the amount of relief available to a single company under this scheme in any one financial year.

(4) Companies seeking the higher rate of tax relief should be **ALLOWED TO POOL** contracted out research funds to jointly fund larger projects.

IMPLICATIONS

An approved academic institution will generally mean a university or polytechnic. The implications for private commercially run research and development companies will have to be considered.

The eligible company size restrictions, and the upper limit on the amount of relief are proposed, to:

(a) Eliminate the very small companies and private individuals from the scheme who would be unable to successfully exploit the products of a research programme.

(b) Encourage medium-sized firms to innovate in close association with specialist academic experts, that under normal circumstances they could not afford to employ in full-time research and development. Such companies will also have the production facilities, the access to finance and the experienced management team in place.

(c) Prevent the major companies from dominating the research facilities at the academic institutions.

INDIRECT BENEFITS

The proposed scheme will:

(d) Encourage the maximum contact between academic institutions and innovative companies without the editing and filtering effect of approval bodies. Civil servants and accountants have a duty to protect the resources in their charge, which is directly counter to investment in often speculative research.

(e) A tax relief based scheme as proposed would be relatively "red tape" free, easy to implement, and still require companies to make commercially sensible decisions over the investment of part of their research budget.

(f) Direct contact with commercial firms would make the academic staffs of the universities and polytechnics more aware of the markets' needs and costs restraints.

(g) Direct contact with the academic staffs would make the design and marketing employees of commercial firms aware of the latest developments. Technology transfer would also play an important role.

MEDIUM-TERM BENEFITS

The most significant medium-term benefits would be:

(h) That the increased funding available to the academic institutes could be employed, at the direction of their governing bodies, to either improve the teaching facilities or improve the equipment in the research laboratories. The better institutions would attract the largest amount of funding. The greater funding and better research equipment would be available for fundamental academic research projects.

(i) Specific institutions would in due course develop considerable expertise in defined areas, and become centres of excellence.

A WARNING

The above proposal covers the academic/commercial interface for immediate economic gains. Other areas that are skill and finance intensive, and concerned with long-term fundamental research need a different more national and strategic approach.

When people talk in terms of innovation they tend to refer to new products. However, the greatest commercial advantage for Britain lies in using our existing research expertise to increase the added value and quality of EXISTING PRODUCTS.

J P O'CONNOR
Consultant
4 July 1990

Letter from John Osola and Associates Limited

In a recent conversation you referred to the apparent effect of short-term financial policies, in certain manufacturing companies, on investment in new plant and equipment and in research and development.

This brought to my mind one large British company for which I have acted as a consultant. The company was for many years in public ownership as part of a British nationalised industry. During the 1980's it was privatised and was subsequently acquired by a large French industrial Group who have actively encouraged its further development.

During its period in public ownership the company's management were only permitted to submit proposals for capital investment in improved plant and equipment if a payback period of 1½ to two years could be demonstrated. This restricted the company's capital programme and severely limited the freedom of management to put forward a number of imaginative projects which could have improved manufacturing performance and competitiveness.

The new French owners invited the management to reconsider their forward capital programme on the basis of payback periods of three, four, or five years, or even longer in cases of special strategic importance.

The company now works to a general target of up to four years payback but is pushing ahead with one important project where the payback period is expected to be about six years. The French parent company itself works to a payback period of up to six years in considering its own capital programme.

There is recent evidence that some Japanese companies in the same business sector are willing to invest on an even longer timescale.

I need hardly emphasise that the impact of a change in financial policy from say 1½ years payback to five years payback is substantial and will profoundly affect a company's competitive capability within a decade or less.

JOHN OSOLA
24 *October* 1990

Memorandum by Professor J M Owen, School of Mechanical Engineering, University of Bath

THE DTI STORY

SUMMARY

In 1987-88, negotiations took place between senior engineers, academics and DTI officials to fund a £600,000 three-year research programme on gas-turbine cooling systems. Although the programme was technically sound, it was rejected, apparently at ministerial level, after nine months of discussions. The engineering companies were labelled as LRUs: "large and regular users" of taxpayers' money. This unexpected decision nearly caused the demise of an internationally recognised university research group.

CHAPTER 1—LOOKING FOR A NEW PARTNER

The story begins in Autumn 1987 when I was Deputy Director of the Thermo-Fluid Mechanics Research Centre (TFMRC) at the University of Sussex. Professor F J Bayley, the Director, and I had been successful in obtaining a number of large research contracts to study effective ways of improving the cooling systems of gas-turbine engines.

This work had been sponsored by the Science and Engineering Research Council, Rolls-Royce and Ruston Gas Turbines, as well as by a number of European gas-turbine manufacturers. The research had been recognised by the award of the first prize of £25,000 in the 1985 Academic Enterprise Competition sponsored by the British Technology Group. After having received two three-year co-operative awards for around £600,000 each from SERC, we were advised that this amount of money would no longer be available and we should look to other sources for financial support from September 1988.

Chapter 2—The come-on

Around this time the newspapers were featuring large advertisements for the newly styled Department for Enterprise, which had emerged from the old DTI. There was a new spirit of enterprise in which, apparently, increased funds were available for co-operative research between universities and industry. This timely development struck a chord with Professor Bayley and myself, and we approached Mr Colin Sansum of DTI.

Chapter 3—The courtship

Mr Sansum was very helpful and confirmed that DTI were indeed trying to improve collaboration between universities and industry. After discussions with Rolls-Royce and Ruston Gas Turbines, we submitted an application to carry out further research into the cooling systems of gas turbines for a period of three years. The total cost was £600,000 of which Ruston and Rolls-Royce would provide half, and the DTI the balance.

Our first written application was revised at the request of Mr Sansum, and meetings were held at the DTI offices in Kingsgate House, London. At one such meeting, which was held on 29 January 1988, senior engineers from Rolls-Royce and Ruston attended together with Professor Bayley and myself. An independent technical adviser, whose job it was to assess the technical merits of our application, was also present. From this and other discussions it appeared that there was a good chances of success, and Professor Bayley and I began to make provisional plans for the programme to begin in October 1988.

Chapter 4—The brush-off

Over the coming months conflicting signals (by telephone but never by letter) began to emerge from DTI. It was revealed that Rolls Royce and Ruston Gas Turbines (the latter organisation being part of the GEC Group) were labelled as LRUs: in DTI parlance this meant "large and regular users" of tax payers' money. These organisations were looked upon by ministers as pariahs who had received more than their fair share of money from DTI. (It should be pointed out that these two British companies are the *only* ones who sponsor significant gas-turbine research in this country, and both have excellent records of export achievements!)

The signals began to indicate that we should not receive the full 50 per cent from DTI, as originally hoped, but there might be a formula in which we received 40 per cent for the first year, 30 per cent for the second and 20 per cent for the third. Even this prospect of reduced financial support for our three-year research contract was dashed by a phone call in July 1988 in which we were told that a decision had been made "at ministerial level" that no money would be made available from DTI.

Chapter 5—Picking up the pieces

After around nine months of negotiations with DTI, Professor Bayley and I face the collapse of TFMRC. The contracts for most of our 12 Research Officers and technicians were due to end in September, 1988, and there was little time to find alternative funding.

Faced with this prospect, Rolls Royce acted with great speed and obtained support from the Ministry of Defence to provide a brochure of £300,000 to fund part of the programme. I spent most of the period between July and September of that year writing out details for the MOD brochure together with two applications for funds from SERC. Fortunately all applications were successful, and we were able to obtain around £500,000 worth of funds. This "eleventh hour appeal" had averted a near disaster.

Chapter 6—Epilogue

In October 1989 I was appointed to the Chair of Aeronautics and Thermodynamics at the University of Bath, and since that time I have been awarded grants totalling £400,000 for continuing research into cooling systems for gas-turbine engines. This money has come from SERC, Ruston Gas Turbines, Ministry of Defence and Motoren-und Turbinen-Union, Munich: none has come from DTI.

Unless I can be assured that there has been a change of policy within that organisation, I am unlikely to apply for funds from DTI in the future.

Professor J M OWEN
20 *February* 1990

Letter from Professor K Pavitt, Science Policy Research Unit, University of Sussex

Thank you for your letter of 13 March 1990 on which you ask for submissions on the above subject. I shall make my submission as brief as possible. If you would like further information, or supporting documentation, I shall be glad to send it to you.

1. Throughout the 1980's, the UK has continued to be the major OECD country with the slowest rate of growth of innovative activities, whether measured in terms of R&D of US Patenting.

2. Survey evidence suggests that UK managers give lower priority to innovation than do their major competitors.

3. Compared to other European countries of similar size, the UK is well positioned to take advantage of foreign technology. A relatively high proportion of technological activities of UK companies are performed abroad. Similarly, a relatively high proportion of technological activities within the UK are performed by foreign firms.

4. Our studies show that conditions in the home country influenced the technological performance of even the largest and most multi-national of firms. We have suggested that the British system is "myopic" in neglecting the role of R&D and training in creating "intangible" assets in firms.

5. However, the economic environment cannot be blamed for all problems. There have been major disparities in British technological performance in different product groups. Chemicals and aerospace have done well. Automobiles and electronics have done badly. These disparities have emerged as the result of differences in management policies in a relatively few large firms.

6. In relation to defence R&D, the high UK commitment must be reconsidered in the light of both the recent changes in Central Europe, and the increasing dependence of defence on civilian technology (and not *vice versa* as in the past). In such circumstances, under-investment in civilian technology can become a strategic problem.

Please do not hesitate to write if you think that my colleagues and I can be of any further use.

PROFESSOR KEITH PAVITT
Deputy Director
16 *March* 1990

Memorandum by Mr James Pilditch

LEARNING FROM WINNERS

A WORD ABOUT DEFINITION

The House of Lords Sub-committee gives as its definition of innovation: "the economically significant application of new knowledge and techniques".

This is a marked and welcome step. So often, until now, people have thought innovation is the preserve of science, expressed in industry through its R&D departments.

The committee's definition implies—and a sad history of brilliant failures confirms—that other skills are involved. So they are.

We think, too, of innovation applying to products (and this submission is written that way). But that is too narrow. American consultants Arthur D Little see innovation occurring in at least the following areas:
Product, service, marketing, production, distribution, finance, management and social.

It should be noted that while Japanese companies already given more time to innovation than we do (1), they expect to put *far more emphasis* on innovation in every area listed above except one (management). See chart (2).

One encouraging aspect of both the House of Lords definition and of the newly-appreciated breadth of innovation, is that companies may not need huge investment in R&D to innovate well. The door is open to everyone.

Q1 *What are the effects of company attitudes and structures, including personnel policies and investment decisions?*
It is exactly right that this should be the first question. A company's ability to innovate is dictated, above all, by its attitude and structures. Of the two, the first comes first.

In 1985 NEDO (National Economic Development Office) set up a working party to find how some firms seem to develop, relentlessly, the goods we all want to buy. That, at least, is the definition it soon gave itself.

NEDO commissioned a study, led by Mr James Fairhead, to look at some of the most obviously successful innovators in the world.

At the same time, it commissioned independent market research among engineering-based manufacturing companies in the UK.

The idea was to see whether exemplary firms behave in the same way as the generality. If they differ, how do they?

Fairhead's answer was startling.

Yes, he said, companies which innovate successfully and consistently are different from others. And what is the difference? "What all those companies have in common," he said, "is the same 'corporate culture'".

At the time critics called that "airy-fairy" and "pie-in-the-sky". With more study and more understanding, this author, at least, believes Fairhead hit the right point precisely.

On the next pages are some of the NEDO findings. To add to the picture, summaries of three other studies follow. As the ideas repeat themselves, the touchstones of successful innovation become clear. Equally, obstacles to innovation are easy to spot.

CHARACTERISTICS OF SUCCESSFUL INNOVATORS

1. They *care about products*. They believe they exist to make products people want to buy.

This is unlike the attitude of many British—and American—companies which often put short-term profit first.

(On a visit to Japan, a study group (3) looked at how Japanese firms develop new products. They came to compile a list of silly questions. One was "How often does the board look at new products?" After a puzzled pause, the answer, invariably, was "all the time".)

Any British product designer will tell you that trying to talk to manufacturing companies here is a forlorn experience. They are not interested. Their priorities lie elsewhere.

2. *Obsessive about customers*. Borrowed from Peters and Waterman (see below) this urgent phrase sums up the attitude of companies which innovate successfully.

All companies would say they care about their customers. Yet when the Open University researched this they found two-thirds of companies interviewed expressed their objectives in terms of profits and sales. Fewer than one in five (17 per cent) expressed their main objectives in terms of meeting customer/user needs. This is corroborated by a study conducted by the Chartered Institute of Marketing in 1984. It found about one company in five conducts consumer surveys (4). The reason most often given for not doing more was "we know enough about our customers already". This luxury is NOT shared by the innovative companies.

Nor, in successful companies, is this thirst for knowledge of customer behaviour and wishes confined to the defined marketing or market research people. Everyone is involved. R&D people make service calls, engineers talk to shoppers loading their cars, chairmen talk to customers.

3. Intense *analysis of competitors* is another common theme. Kenichi Ohmae, head of McKinsey & Co in Tokyo, has observed that "competitors set the standards we have to beat".

Yet see this: in 1986 Korn/Ferry International asked directors the relative importance to them of a number of issues. Fewer than one in five (17.5 per cent) put industry competition in their first three places of importance.

To glimpse how effective thorough understanding of competitors can be, see the case history stated briefly on page 248.

The critical point is already clear. To innovate successfully companies have to satisfy customers better than their competitors do. Without knowing what customers look for, and without knowing how competitors respond to those wishes, that is hard to do.

4. Successful innovators integrate design in a *multi-disciplinary process*. When Japanese executives speak of their design department they mean an integrated team—of engineers, scientists, manufacturing, design, marketing, sales, finance, customer research and more besides.

That is the design team. In innovative companies it is, always, working together for the length of the project, close to the board, at the heart of the business.

5. In other words, innovative companies *break down the walls* that divide one discipline from another. Most companies are organised by function—R&D, engineering, finance and so forth. Each department is a fiefdom to defend. Communications, such as they are, flow down and up.

Successful innovators alter all that (see page 247).

Breaking down walls, and communicating well, are matters of attitude. But there can be a physical dimension, too. Buildings, and enclosed offices, don't always lend themselves to easy co-operation between people. Unilever, at Port Sunlight, where there are 1,100 researchers, say that by redesigning their laboratories they have improved the flow of research and now develop new products more quickly.

6. Companies that innovate have a *product strategy*. Whether they want to compete by being more advanced technically, or by being cheapest, or having the best distribution, or being first in the market, or having the highest quality; whatever it is, they need a consistent strategy.

7. They *chase technology*, too. They seek it where they can and, often, buy in all they can. But note: even in Silicon Valley (5) they say "competitive advantage is not achieved by technology, but by how you relate it to the customer".

It is important to add that this search for technology should not be confined to the industry you are in. Major innovations which affect an industry often come from outside it (6). To look only at direct competitors, therefore, could be to miss the big opportunity.

8. Innovative companies *co-operate with their suppliers*. They forge lasting relationships, seeing them as "partners" in the development process. They choose suppliers on the basis of quality and reliability, rather than low cost. The common practice today, of keeping suppliers at arms length, then choosing on cost, is not conducive either to innovation or to quality.

9. Part of the same approach, innovative firms *demand quality*. They design quality in, rather than inspect faults out. (Japanese companies, so many of which have impressed the world with their consistent quality, employ one-fifth the number of quality inspectors of their British or US counterparts). (7)

10. Common to all successful innovators, it seems, is a very high level of *open communications*. If they know what your goals are, people in the firm can use their initiative to help achieve them.

Four other points

11. *Quality, not price*. In Britain, particularly, there is widespread belief that low price is the key to competition. Repeated studies say this is not so. As much as 80 per cent of imports of manufactured goods to this country, one report stated, are based on so-called "non-price", factors—quality, uniqueness, reliability, service, design, etc., (8) Successful innovators sell on quality, not price.

12. *Sustained training*. It will be hard to solve tomorrow's problems with yesterday's competence. According to some sources, spending by British industry on training is maybe one-seventh or one-tenth that of our competitors in the EEC and United States. To say nothing of Japan. (9)

13. *Speed* is unquestionably an element of successful innovation. Again, Japanese companies (though not only them) stun their competitors by the sheer speed of their product development. They say they use speed to "shake out" slower competitors. Many have sliced in half—and better—the time it takes to think of, develop and market a new product.

One fundamental implication is that any system for new product development MUST put a premium on swift action. The careful, measured tread we are used to won't do. (Ways to speed the process are described later on page 247).

14. *Intensity*. What distinguishes the driving, innovative, firms is the intensity with which they do the things others say they do.

More characteristics of successful innovators

James Brian Quinn is Professor of Business Administration at Dartmouth College, New Hampshire. He has studied innovative companies of all sizes in a number of countries. Here, to paraphrase him, is what he has found time after time.

1. The need for *atmosphere, vision* and *a feeling for people*. See how he puts this first.
2. A *technological strategy*. Whether a company looks for major developments or step-by-step improvement, whether it resolves to make all it can or buy-in, it needs a strategy. (10)
3. A company must be *market/goal* oriented. This is not confined to consumer-goods firms. It applies to everyone.
4. There is always a *champion* who drives success. (Arthur D Little speaks of three: a technical champion, a business champion and an executive champion to sponsor and protect the idea at the highest level).
5. Successful innovators, claims Quinn, always develop what he calls "*multiple approaches*". That is, they never run with one idea alone. "The nature of innovation" he says "is that you don't know". Internal competition is not wasteful. It creates new products faster.

6. Quinn talks of *inter-active learning*. Successful companies learn from customers, suppliers and others.
7. "*Don't set up normal structures if you want to develop new products quickly*" advises Quinn.
8. *Rewards and incentives* are essential. Nor should these be simply financial.

Turn to a third summary:

In 1979 the CBI (Confederation of British Industry) published "Innovation and Competitiveness". It listed seven significant factors in product development.

1. Responsibility for product and process development is vested in *a member of the board.*
2. Support and/or participation by the *chief executive.*
3. Good rapport between *marketing, production and development.*
4. Effective use of *external sources of technological help* and advice.
5. Close *collaboration with customers* in product design.
6. Presence of *technologists on the board.*
7. Effective *screening of ideas* and monitoring progress of approved projects. (Take care: there are dangers in this. It is wise to remove from the innovative process many controls necessary in a big company.)

Although Peters and Waterman's "In Search of Excellence" was about highly successful corporations, their findings fit innovative companies. They noted, as common among brilliant firms:

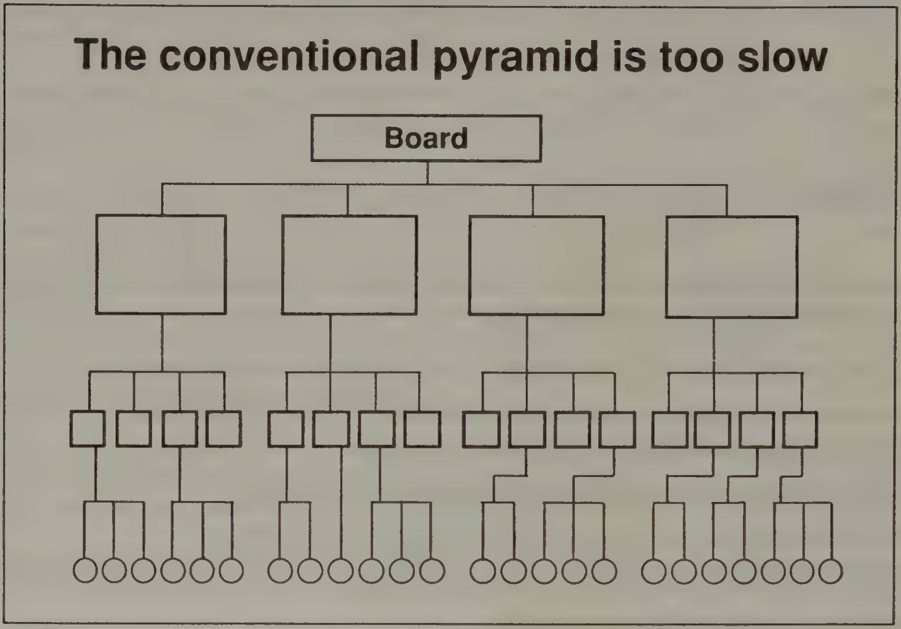
1. A *bias for action,* for "getting on with it". (As I will describe, the systematic methods of well-ordered companies are just too slow.)
2. *Close to the customer.* They speak, repeatedly, of "an obsession with customers".
3. *Autonomy and entrepreneurship.* This implies devolving responsibility, letting people set their own goals and run their own show.
4. In the same vien, they talk of "*productivity through people*". People achieve results, plans don't. The way companies treat people governs how well they innovate—or do anything else.
5. Peters and Waterman note how driving companies are *hands-on, value driven.* You hear of the chairman of Sony carrying his products around with him, the president of McDonald's cleaning tables, researchers at BELL making service calls.
6. Successful companies *stick to the knitting.* This is not the same as sticking in the mud. It means doing what you're good at, and improving all the time.

From four perspectives we see what seem to be characteristics of companies which innovate successfully. The mosaic adds up to a picture of another kind of company, different from the norm. Underlying all the particular behaviour, one senses, is fresher, simpler attitude, a more direct way of going about business.

This is probably fundamental. Christopher Lorenze of the *Financial Times* was once asked why other companies don't innovate as well as 3M. "They copy the systems," he replied, "but not the culture.".

ORGANISATION AND STRUCTURE FOR INNOVATION

While there are as many organisation structures as there are companies, often the shape looks like this:



It looks like a pyramid. It is divided horizontally in a hierarchy and vertically into divisions or departments. Communications, such as exist, flow down and up.

One snag is this: people *throughout a company* are involved in the innovative process. Existing organisation structures hinder that process.

Wherever an initiative starts (maybe with R&D, maybe marketing) conventional progress is not so much linear as like crossing the Alps. One department does its work. That work passes up, for approval, then across to the next department, then down to the people concerned. Up and down the company it goes. If something doesn't work, back it goes—up, across and down.

Even when the journey is less hilly, it is still sequential, one step before another.

There are at least seven things wrong with this normal process.

ONE, hierarchies work against risk-taking.

TWO, research shows (11) many firms do not involve all departments in either the start or finish of a development project. They are unlikely, as a result, either to share the same goal or to feel committed to the commercial success of their work.

THREE, each department strives to achieve its own idea of excellence, whether that is what the customer wants or not.

FOUR, this linear process has its own pecking order. Some roles are thought worthier than others. To this day, often, manufacturing is still told what to make, marketing is told what to sell.

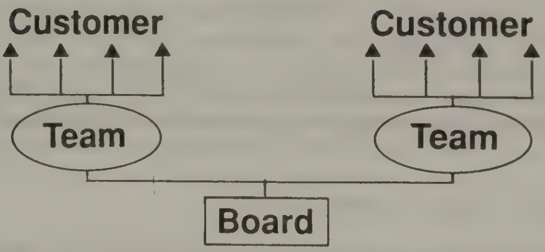
FIVE, this process, including the "iterative" bits of it, is slow.

SIX, it is wasteful. Good people, in their isolated departments, can work for weeks or months on concepts that may later be proved useless; designs that cannot be made, technology nobody wants, and more.

SEVEN, where does the customer come in? Often, sadly, at the end, when commitments have been made, high tooling costs incurred.

A better way looks like this:

The faster, focussed way



- **Focus on customer**
- **Multi-discipline team**
- **Close to decision-makers**
- **Communicate across the company**

Bring people *from every relevant discipline together for the life of the project.*

Form a team (or competing teams). Put it close to the board. Give it, as a goal, the task of creating a product customers will prefer to any other on the market—or likely in the foreseeable future.

Everyone in the team then has the same goal. Together, they argue differences, inject their knowledge to each part of the process, stimulate each other.

The board supports, encourages, enables. It takes care NOT to control too much.

Consequences are:
More ideas are developed *more quickly*. They are more likely to be oriented towards the *customer*. The *quality* of the end result is better. And the whole process *costs less*.

ESSENTIAL POINTS: One: this way is quicker than the linear approach. And speed matters. Two: innovation is a creative process, one of trial and error, failure and occasional success. Like any creativity, it is a muddly, chaotic, disjointed, disorderly process. To succeed, companies must appreciate that.

How is the well-ordered firm to cope with chaos? Some form what they call a "skunkworks". This is a small team of creative people (from various disciplines) put together in a separate building near the main board.

It has a simple brief: develop new products—and get on with it. The team is free of normal rules. It can scrounge what it likes where it likes. But it must get on.

The analogy of a small commando within a large army may fit.

Some large companies have tried every organisation there is. They've put innovation out to divisions. Today some have drawn these back to the centre, though they work across all divisions, and often assign people to them.

Two characteristics, already noted are:
One, *everyone* on the team is involved in finding out *what customers want*. (That is NOT usual in the conventional firm).

Two, designers and others, can spend up to half the year *out of the office*—with customers, dealers, suppliers and others.

SMALL COMPANIES WELL PLACED

A revealing point of organisations is this: large companies which innovate successfully try to behave like small companies.

James Brian Quinn has looked at this. He believes small companies have many of the qualities large companies should imitate.

He says that to innovate you need "a *fanatic with expertise*". One's own observations might confirm this. One difficulty: large firms find it hard to cope with fanatics. If they hire them in the first place, they soon lose them.

Big companies, Quinn says, *expect too much too soon.*

He adds that they doom projects by managing them like anything else. The financial department gives each project a job number and assigns to it a share of both direct and indirect cost. The whole thing becomes too costly too soon. Small companies, by contrast, *keep early costs low*. (they have little choice). They are *need-oriented;* they must have new products to stay in business. They are *flexible*. They *tolerate chaos* and have *few early formal plans.*

"Just do it and see what happens" is their approach. That is not the language of the coolly organised, financially dominated large corporation.

According to Quinn, these are all qualities of successful, innovative companies. Aware of this, some big companies strive to emulate small companies.

SHORT STEPS

Another vital point affects organisation. It is possible, though misleading, to think that innovation is a large process, of taking big steps.

The Japanese say that a hundred short steps can be better than one large one. Indeed, you hear they demolish competitors with "a thousand cuts".

An exemplary British case is J C Bamford (JCB). They run a twin-track policy. On one hand, they look for a major product innovation every eighteen months or two years. On the other, they improve their products little by little all the time. In 1989 they introduced over 100 improvements to their products. These can be minor; a better wing mirror, a stronger bumper.

The consequence of this—and wonderful performance in other ways—is that JCB enjoys market leadership in over 50 countries.

Organisation: a telling case history

A McKinsey & Co executive, Robin Leaf, once described how two firms addressed the same problem. The case shows how original structures can speed the innovation process.

Each company had identified an opportunity for a new product (to protect confidentiality, Leaf called it a dishwasher, though it wasn't).

In one company, the chief executive asked the R&D department to develop a product. He set up a series of pilot projects; to look at the merits of different solvents, to examine the cleaning action of different jets, the best way to arrange crockery, and so on. At the end of the year the R&D director knew a lot about "dishwashers" and even had one running.

That was a traditional approach.

The competitor was Japanese. Here is what it did, from the same knowledge that there was a gap in the market.

First, it bought three models of every available "dishwasher". Then it formed four groups.

- A *product test team,* of marketing and technical staff.
- A *design* team of technologists and production people.
- A *distribution team* of marketing and production staff.
- A *field team* of production staff.

The *product* test group was given one model of each "dishwasher" on the market. Its task was to evaluate its performance. (How well did it wash dishes? How easy was it to use? What were the periods between breakdowns? What were the reasons for failure?)

The *design* team was given the other two models of every "dishwasher" on the market. It tore them down (reverse-engineered them). All the machines in one set were stripped to calculate the number and variety of parts, to assess the cost of each part and of their assembly. The other set was stripped down to "life-test" each part, to identify design improvements and to develop a comprehensive picture of each competitor's technology.

The *third team* looked at each competitor's marketing and distribution system. It looked at the number of outlets each was sold in, the service offered and availability of each product.

The *field team* of production staff was charged with looking at competitor's factories. It had to assess each competitor's production facilities in terms of labour costs, costs of supplies and productivity.

AFTER ONE YEAR

At the end of a year, that Japanese company still didn't know much about how fluids clean dishes, but, according to Robin Leaf, they knew enough to build a dishwasher which was better than any competitor. It also *cost 30 per cent* less to build. Within the same year, they also had a *marketing plan* which positioned the product in relation to its competition. They had also defined the *amount of stock* and *service* needed to do better than their competitors. Finally, and amazingly, they had a *plan for building a new factory*, establishing contracts with *suppliers* and *training* the workforce.

As a result of this focused approach, the Japanese companies came to market two years ahead of the traditional company. It achieved its forecast market share. The rival, according to Leaf, "lost some money and dropped out of the market".

This case is described to emphasise several points.

First, the Japanese example was not a linear progression. Four teams worked in parallel.

Second, different skills were mixed . . . in surprising ways. (Professor Colin Clipson, who runs the "Competitive Edge" project at the University of Michigan, has noted that innovation and originality comes at the points of overlap between disciplines.)

Third, the emphasis seems plainly to have been to find out what competitors do—and do it better.

Fourth, as clearly, to the Japanese company the innovative effort embraced the WHOLE process of creating a product and getting it to market. (The US Department of Commerce defines *innovation* as: the WHOLE process of moving new goods and services profitably into the economy.) In this example, not simply the product was worked at but, at the same time, its distribution, marketing, pricing, method of manufacture—even training.

IMPACT OF INNOVATION ON PERSONNEL POLICIES

While based on sensible analysis of facts, innovation is a *creative process*.

It follows that companies should strive to provide the environment and atmosphere in which people can stretch their imagination. This applies to everyone, not just the nominated "creative" people.

To be creative, people need freedom, encouragement, support. It is not difficult to motivate people, say Arthur D Little. It it very easy to demotivate them. "Bureaucratic hassle", they say, is the fastest way.

Peter & Waterman speak of "*productivity through people*". Evidence suggests that the unusual hierarchical, stratified systems by which people are regulated are unlikely to stimulate innovation.

The appropriate attitude is looser, more relaxed, more trusting.

Reward is important. This may not be, and should not be, only financial. Recognition can count for at least as much. IBM offer research fellowships and sabbaticals to people who do well. Some Japanese companies reward people on successful innovation teams by letting them sit on another. They call it "pinball". If you win, you play the game again. A point amplified under "organisation and structures", people on an innovation team may be separated from the main run of a company. Perhaps their rewards should be too.

The approach to pay may need to be more *flexible*. In industry people tend to be recognized for their short-term performance; how well they hit this year's targets. That may deter ambitious people from working on projects which can take years to pay for themselves.

In Singapore, the head of Cerebos Pacific is trying to find a way to reward executives who take a longer view. He wants them to share the fruits of a successful innovation when it does come to profit, even if that runs into their retirement.

A difficult point for managers: they must *let people fail*. Engineers and others who are not allowed to fail will play safe, using proven (yesterday's) ideas, processes, materials. Risk is part of innovation. People not directly concerned with the innovative process (boards, personnel managers and finance directors among them in this context) must appreciate this.

The way people are judged matters in other senses. For everyone concerned with innovation, there is a need to be in the closest touch with customers. They can't do that sitting at their desks. So personal managers, in so far as this touches them, must forget the nine-to-five-sit-at-your-desk mentality.

As far as it affects them, personnel managers should do all they can to "break down the walls" between disciplines.

It cannot be said every company has the skills needed to innovate well. They may need to *hire other kinds of people*.

FOR EXAMPLE: Companies need someone on the board able to *explore new technologies*.

FOR EXAMPLE: Generally companies need to know MUCH *more about their customers*. People able to search for and appreciate the needs and wants of their customers are essential.

FOR EXAMPLE: If divisions remain between engineering designers and engineers concerned with manufacturing, they should cease.

FOR EXAMPLE: As well as being creative, innovation is, of its essence, competitive. People and resources are needed who are able to analyse competitors and their products (see case history, page 248).

FOR EXAMPLE: Business today depends on *information*. Companies which innovate successfully tend to be far more open and more questioning than the generality. As a result, they are better informed. As well as spreading the attitude throughout the firm, there is every case for developing vigorous marketing and technology-based information activities.

Doubtless, other skills are needed, too.

Training

Perhaps training fits under this heading. Any comparison at every level, from boardroom to shopfloor, insists that people in British companies are far less trained than their counterparts in other leading nations. Within the UK, companies which innovate well spend more on training than the average. The point needn't be laboured here, except to say:

1. We won't develop tomorrow's products with yesterday's know-how.
2. Training for everyone should be continuous.
3. People should move from department to department, to understand them.
4. As part of training, everyone should be encouraged to go out, to meet dealers, suppliers, customers, others.

Impact on innovation of investment decisions

The nature and size of the company determines this point. Some companies may need to stay in the forefront of technology and should invest accordingly. Others do not. Some *generalisations* may be:

According to a study conducted in 1979 by the University of Virginia, it takes up to seven years for a good innovation to make a full return on investment. Even if that is thought pessimistic, it is clear that innovation does not yield quick profit.

This is enough to discourage all but the visionary. Nonetheless, ways must be found to help companies take the long view. Pressure on public companies make that hard. But most potentially innovative companies are not public. They don't need to declare rising profits each half-year. But they have other problems. Many feel they haven't the money to invest in anything but the immediate. Nor do they feel they can spare people for training.

Banks could help. With the glowing exception of 3i, most don't.

By investment, one tends to think of investment in tangible assets, plant or equipment which can be capitalised.

Here, the general picture is not good. British firms seem *far less* interested in investing in computer-aided design, computer-aided manufacturing, robotics, or flexible manufacturing systems than their equals in other European countries (12).

"The pressure" according to Colin New at Cranfield "seems to be on the search for short-term payoffs" (This) he said "drastically inhibits the pursuit of long-term strategies, particularly in relation to market-share dominance and new technology".

You hear the same, sad, story wherever you turn. "Short-termism" is a desperate drawback.

Regretting this, there are three glimmers of hope.

The *first* is that many successful innovators *buy-in* all they can. The more technology advances, expands and explodes, the more sense there is in doing so. (That is NOT good for Great Britain Limited, but can be wise for many individual firms). A few firms, of course, must be in the vanguard of technology. But that is neither possible nor true for others.

Without doubting the need to invest in new plant and equipment, that, too, can be a drag. You often come across companies which commit the solecism of designing products more to suit the factory than the customer. It might seem sensible, and please accountants, but can be suicidal.

The *second,* is that there are other perhaps less costly areas of investment. Many companies might do well to recast their investment to *strengthen gaps* in *their skills.* And to spend more on tasks they don't now do well.

Competitive product analysis is one example. Market knowledge is a second. Technology search a third. Design a fourth (13). Training another.

Third, reorganising the company to raise quality is also a cost. On the other hand, defects cost more. Investment in systems for better quality is drastically overdue (14).

Fourth, while reorganising existing resources, as described, might deliver far better results than average companies generally achieve, there is a cost to this.

Fifth, as we've seen, there are at least seven areas of innovation. Of these, it is possible that product development is the most costly. Improving *other areas* may yield good results, again, perhaps without high cost.

But that is clutching at straws. The essential point remains that the generality of companies do not invest adequately in innovation, nor are they encouraged to do so. Short-termism rules. Not OK.

Q2 *How active are UK companies in seeking out external technology, especially from overseas? How well do they adapt and apply it?*

The question is apt. Companies need more technology transfer. But research findings are not encouraging. In 1984 PA Consultancy Group found that only one in five British chief executives thought technology would have an impact on their business. (10) At the same time, over half thought their products more advanced, technologically, than their international competitors. With this coupling of complacencies, it is hard to believe many seek technology from outside.

We may hope the position has improved since then, although in a further study (15) conducted in 1988, PA still regretted "the low priority accorded to harnessing new technology and mangement techniques for product and process development". To be unaware of advances in other countries is to be blind. To attempt to develop one's own technology to beat the best in the world, while essential for a few firms, is beyond the scope of most. Licensing becomes vital.

Aware of this, the United States government has even relaxed its anti-trust laws. It now allows rival companies to undertake joint R&D projects. There are said to be over 200 working partnerships in existence now. At least one Wall Street firm funds such projects.

At home, universities can be a source of technology. While there has been progress in recent years, this picture isn't as it should be. In 1985 Arthur D Little found nine British companies in 100 thought academic institutions good places to get ideas. By contrast, 45 per cent of Japanese companies look to universities for ideas. In the US, too, companies are getting closer to universities, investing heavily to build laboratories close to campuses.

I cannot say how well British firms adapt and apply new technology.

Q3 *Respective roles played by product development and production engineering in technological innovation.*

Who develops products? Is it done by design engineers? Or industrial designers? Or marketing people? Perhaps the answer is all of them.

What has been said, is that product development in average companies, is a linear process. NEDO research (11) suggested that 61 per cent of companies do not involve manufacturing in the start of the process. As Sir Robert Telford, life president of Marconi, has said "the factory is still told what to make".

If, as Sir Monty Finniston has said "designers are the aristocrats of engineering", production engineers remain well beyond the chateau gates.

That is to be regretted. It has been estimated (16) that 80 per cent of the cost of a product is dictated by design—and that must include skilful design for manufacturing.

The divide between design engineers and production engineers is wide. A Japanese observer noted that when Japanese engineers graduate they go to work in the factory. In the US, he said, they drive to a separate car park, and go to work in offices far from the plant. Perhaps British behaviour is the same. (17)

The same is true of R&D. In Hitachi, of 8,000 R&D people, 5,000 work in factories. That ratio seems amazing to us.

Because FMS has such an impact on what can be designed, the closest co-operation between manufacturing and design and marketing is called for today.

The linear process acts against the smooth integration of production engineering into the product development process.

The close relationship of industrial designers with manufacturing is also essential. How often are designers accused of creating things that cannot be made? There are two sides to this, though. Manufacturing people can be very conservative, unwilling to change. One role of the consultant designer can be to convince manufacturing that what they believe can't be done can be done (18).

It is also true that unless manufacturing people spend time outside the company they can be unaware of new processes in use elsewhere (19).

Under this question, as others, the same points emerge: the need for multi-disciplinary teams that work together throughout the project, and the need for everyone to be out and about, finding out what is going on and what people want. That applies to production engineers as it does to everyone.

Q4 *How effective are the activities of Government departments in promoting and supporting innovation?*
Uniquely in the world, the Prime Minister has demonstrated sustained interest in this subject. Some Government departments strive to encourage parts of the innovation process. The *Department of Trade and Industry* stands out a mile, though there is some feeling that its enthusiasm is waning.

For a time the DTI ran a number of funded schemes to help businessmen in fields related to innovation. Manufacturing, quality, marketing, design, finance, distribution and so on.

Recently, they embraced the idea of "multi-disciplinarity", by promoting these schemes together, in one package. All are parts of the innovation process.

Since these schemes are without precedent in the world, the DTI is to be admired. However, there are short-comings inherent in them.

First, financial aid is restricted to about two weeks' use of consultants. This may mislead companies to believe the problems are less difficult than they are.

Second, while these schemes bring competent consultants into firms, the risk remains that they continue to work in isolated pockets; manufacturing people not talking to marketing, designers not discussing finance, and so forth. The old, linear, process may continue.

Third, no scheme attempts to tell manufacturers HOW to develop new products, the way to manage the whole process.

Fourth, the DTI's schemes are restricted to firms with fewer than 500 employees. Although the reasoning is sound, it means larger companies fall outside Government schemes. To suppose they should be able to look after themselves ought to be right, but isn't.

We must attack larger firms. While smaller firms create jobs, it is larger ones that affect the balance of payments.

Perhaps one of the most sustained investments by government in anything to do with innovation is the Design Council. Looking at British industry it is possible to ask how much this investment has altered its performance. This is not to criticise the Design Council, but to challenge the remit it is given.

As the House of Lords' definition makes clear, innovation is concerned with new products or processes which make an "economically significant" contribution. That embraces more than design.

If it coupled design with market research, competitive product analysis, manufacturing, marketing, finance and other skills, the Design Council would be more relevant. The same is true of other bodies with a narrow message.

If any body of this kind is needed, it is more likely to be a "product development council" or an INNOVATION COUNCIL which promotes the totality of the process.

The Design Council has had a good effect on education. So, too, has the *Department of Education and Science*. School children now learn the importance of products. There are both "O" level and "A" level courses in design. Tertiary education, too, has a very strong design emphasis.

In one dimension, although it tries, the DES has had little success. If a key to innovation is to "smash the walls" that divide disciplines, the place to start is in education, notably at higher level. It would be ideal, for instance, if engineering students and students of business and marketing, worked on common projects. This scarcely happens anywhere.

Other government departments show little interest in innovation or product development although, in some cases it could help them.

In 1982 NEDO wrote "the public sector is still not realising its full potential to encourage innovation and the development of internationally marketable products through its purchasing".

The goodwill and earnest endeavour of government departments are hampered by an unimaginative *Treasury*.

To stimulate innovation, the Australian government launched a scheme which offers 150 per cent tax rebates. (They created the dynamic Australian film industry the same way). To imagine the British Treasury countenancing 150 per cent rebates is to stretch the brain too far.

A more modest point might counter the blight of "short-termism". Companies hungry for short-term profits, or driven to them by fear of take-over, are unlikely to invest adequately in new product development. Can anything be done about it?

Maybe. In Britain today, accountancy and tax practice allows firms to capitalise investment in R&D. It need not affect this year's profits. Investment in every other part of the innovation process, however, directly hits the bottom line. That is a huge barrier. When people thought invention was the essence of product development, limiting help to R&D may have made sense. Now, when we realise other skills are no less important, it does not.

Whether the government does enough to fund technology I cannot say. Whether it does enough to encourage companies to co-operate with universities and polytechnics (and vice-versa) I am also not competent to say.

The end verdict is that despite the serious efforts of some departments, the government does not do enough to promote and support innovation. Or, to put it another way, while it makes an *input*, this is not always shown to lead to a fruitful *output*.

A bold, *large* initiative is called for, one which pulls together all its divers efforts into one laser beam of common purpose.

Q5 *What are the Effects of City Attitudes to Investment in Innovation?*
Terrible. As a generalisation, the attitude of the Stock Exchange is wholly damaging. The shortcomings are so well known they needn't be repeated here.

The demand for short-term profit growth destroys the long-term competitiveness of industry.

It is no accident that our most successful competitors, Japan and Germany, have a distance between their companies and their stock exchanges. Equally, in the United Kingdom, as in the United States, stock market pressure makes investment in innovation much more difficult.

Companies seem obsessed with getting bigger, by acquisition, but not in getting better.

Not only does this pressure prevent investment, it commits boards to spend their time on financial matters to the near exclusion of all else. This emphasis seeps deeply into companies. Managers see where approbation lies. They, too, can spend their time fussing with budgets when they should be busy satisfying their customers.

Sir Alastair Pilkington said he could never have developed float glass if his company had been public (as it later became). Anthony Bamford, head of JCB, says much the same about his own company's exemplary innovation.

There is something wrong when such experienced men say innovation is difficult in public companies.

Whether the tax and accountancy point mentioned above (and amplified in the recommendations which follow) helps, this is plainly a point to focus on.

3i understand innovation. It takes a long view and invests in innovative companies even while knowing not all will succeed. This shining example suggests something can be done.

Question 6, 7, 8, 10, 11.
Don't know.

Q9 *What are the effects of the varying relationships between companies and their suppliers?*
When NEDO talked to Jaguar about new product development, conversation turned mainly on how Marks & Spencer work with suppliers. This is significant. Behaviour we might have thought peculiar to one retailer now seems to have a wider currency.

Japanese companies, *par excellence,* have the closest imaginable relationships with their suppliers. It has a profound impact on the way Japanese manufacturers develop high quality products swiftly.

They look on their suppliers as partners in the business—and suppliers see themselves this way. This doesn't mean the manufacturers are soft; they seem very demanding. Even so, suppliers do sit on their product development teams. In some cases, indeed, a team of suppliers is expected to think of new products and processes for their customers.

The Japanese supplier structure, at least sometimes, consists of a small number of main suppliers who, in turn, have dozens of component manufacturers working for them.

It seems plain that suppliers are more likely to develop components of value if they know what their customers are working on and want.

The opposite stands, too. If suppliers do not know what their customers want they cannot use their initiative to be helpful. Waiting to be told also lengthens the timescale.

Ordinary firms design a product using components known to exist. THEN they look for suppliers. Thus, they miss much innovative possibility.

As unhelpful, keeping their suppliers at arms length and in the dark, they then send out specifications against which as many suppliers as possible tender. The decision can so often be made on price. If they do not buy the cheapest, then they will choose a supplier who is near the bottom of the price scale.

This is risky, for several reasons.

One, the supplier feels no loyalty, a point inferred already. Second, it is hard to sell quality products if you don't buy quality components. Third, *low quality costs more than high quality*. Study after study proves high quality costs less than low quality (14).

Fourth, it is a misunderstanding, rife in Britain, that the low price of a product determines its success. This is not so. Study after study proves that price is NOT the determinant people think it is (8).

John Deere, the US agricultural equipment firm, says "sell on quality, not on price". And that sums it up.

The relationship between suppliers and manufacturers is, therefore, of fundamental importance to the innovative process.

Obstacles to innovation

Perhaps the most important single obstacle to innovation is that the boards of many firms, no less than others influencing them, remain *unaware of the true power of the competition.* When companies, or whole industries, decline they attribute the wrong reasons.

Complacency is another obstacle to innovation. Despite sufficient evidence to the contrary, many British firms are BOTH unaware of the quality and power of the competition they face, AND believe they're better anyway.

Excessive *focus on short-term profit* is the bane of British manufacturing. It is possible to sympathise with the boards of public companies. If it is not their natural disposition, many feel driven to report ever-higher profit every half-year. This short view inhibits investment in innovation.

Smaller firms also feel constrained, though for other reasons. Banks could help. With the glorious exception of 3i, few do. They, too, seek a fail-safe, quick return.

The truth is that the boards of many companies are *not interested in their products*. Not enough anyway. They have other priorities. You can sit through whole board meetings without hearing a product mentioned. They rarely have the passion for new products you see commonly in Japanese and other innovative companies.

Many *misunderstand innovation*. To some, as one scientist put it, innovation is "a fancy word for invention" (a view the House of Lords sub-committee specifically rejects). Inventions means high science, high investment, not for them.

A fall-out of this misconception is that companies often *look to their R&D departments* to lead product development. "Technology push" remains a popular idea, even though most companies can't afford to be as advanced as the idea implies. Nor is it sensible most of the time. (It springs from the belief that customers will take whatever new technology is offered them, an idea long discredited.)

From that base, too, flows the linear progression of product development. The sequence of many programmes is *from the inside out;* that is, from R&D, through engineering design, through manufacturing, to marketing and sales. Customers are consulted when all the high costs have been incurred. This is an unnecessarily risky way.

Asked how to be successful, an American millionaire once replied "find a need, then fill". Work, in other words, from the outside in. Find what customers want, THEN provide it. This is the key to successful innovation. It applies to technology as to anything else.

Linear product development has become an obstacle to innovation because it is *too slow*. Speed has become a new imperative. Other ways of organising innovation, described earlier, are quicker.

There is another point about organisation. Conventional hierarchies work against speedy innovation. Jan Carlzon, head of SAS, the Scandinavian airline, has said "we take people from the new levelled society and place them at the bottom of the old pyramid company".

Successful companies turn this pyramid upside down. They devolve responsibility, letting people closest to the action decide. This implies a more open, trusting attitude to the people in a business. The way you treat people undoubtedly influences innovation.

Thus, obstacles to innovation include: *stratified organisations, formal relations with staff, secretiveness,* or lack of open communications.

From the same, old culture, *lack of incentive, recognition and reward* may be added to the list of obstacles.

Successful innovators place their customers at the centre of their universe. They spend their time out, with customers, dealers, others. Ordinary firms do not. They are *not close to their customers*. Nor do they do much market research. This blindness has many consequences, all bad. Not least is that management becomes distorted. It focuses on its worries, rather than those of the customer. Control functions dominate. Outward-looking and creative functions are under-powered and under-respected.

Ignorance of competitive performance is another obstacle to innovation. If you don't find out what customers want and don't know how competitors meet those wishes, you are shooting in the dark (20).

People who ARE close to their customers and who DO know how competitors respond must have the advantage.

Insularity occurs in another way. Many companies *do not look out for new technology*. They expect to develop their own. By contrast, companies which innovate well search ceaselessly for new technology. They have someone on the board able to judge it, acquire it and implement it within the firm.

Low quality expectations are undoubtedly a barrier to success. The standards we have to beat are awesome. People who try quality circles give them up. The drive for higher quality, where it appears, is often based on improving present systems rather than incurring the (short-term) cost of new ones.

The conventional way of *keeping suppliers at a distance and in the dark* works against both quality and innovation, too. So does *buying on price*. Successful innovators choose suppliers for their quality and reliability. They regard them as partners in the innovation process.

While education spurs invention (Trinity College, Cambridge, has many more Nobel prizes than Japan) it does little for innovation. This is true throughout the system—including business schools. With few exceptions, MBA students learn little about products. Nor, one fears, do students of most subjects relevant to innovation.

Even when students of different disciplines study on the same campus, they rarely work together. Walls that divide disciplines are built in college.

This wouldn't matter if people were trained by their companies. But they are not, or nothing like enough. *Lack of skill*, from management down, is a grave obstacle to innovation. ("Why should we train people?" one managing director asked. "They're supposed to be trained already. That's why we hire them").

It all adds up, where we started, to a cluster of *outdated attitudes;* the wrong "corporate culture", as the totality is called.

One analysis of successful innovation after another points to a style of running a business which is different from the norm. It is lighter, faster, more "hands-on", "value" driven, unhierarchical, more open, trusting. It puts its CUSTOMERS, PRODUCTS and PEOPLE in the business as its priorities.

Why don't more firms follow attitudes known to work?

1. As we've seen, they don't put the same emphasis on creating products, or on their customers —so these ideas are irrelevant.
2. Perhaps they don't know about them (more myopia).
3. These new ideas seem the opposite of those learnt about management.
4. The practical people who create products suffer the whims of accountants, and financial people who are concerned with next month's numbers.
5. Innovation is costly and uncertain. Falsely, growth by acquisition appears safer.

In short, while it is easy to blame Government for industry's short-comings, the obstacles to innovation lie within companies. Little is suggested here which is beyond the reach of most firms. They just don't do it.

CONDITIONS WHICH STIMULATE INNOVATION

— Someone with *vision* on the board, ideally the chairman.
— Freedom to invest in long-term development.
— Approbation for doing so.
— An outward-looking environment.
— A flat, unhierarchical, goal-oriented organisation.
— Conditions in which everyone shares an "obsession" with customers.
— Detailed knowledge of competitors.
— Someone on the board required to deliver new products, and with the power to cut across all divisions to get them.
— Multi-disciplinary teams, freed from some of the constraints of corporate control.
— Someone on the board responsible for seeking, acquiring and implementing new technology.
— Close links with suppliers.
— A short time frame.
— Access to money, including "soft" loans.
— Readiness to run risks, no penalties for failure.

RECOMMENDATIONS

The NEDO design working party has made recommendations. These were addressed to particular audiences: the DTI, NEDO itself, the financial community, the world of education and so forth. Some may remain relevant, especially those dealing with "short-termism".

They were segmented on the advice of psychiatrists who were asked the best way to influence behaviour. They said the more particularly your message is addressed to an audience, the more likely it is to be received and accepted.

The DTI, over years, has segmented its messages too. But perhaps these have been by function more than audience. That is to say, various parts of the innovation process have been dealt with: "Design for Profit" was one, the National Quality Campaign was another. There are lots of other examples.

Has the essence of innovation been neglected? Innovation is, above all, a multi-disciplinary process. There is a need to tell people this totality. The best R&D will avail little if the market isn't there. The most efficient manufacturing won't help if the product is unwanted. And so forth.

Any message that ignores this totality will only partly work.

The key to innovation lies in the will of the individual company. The paper, is full of practical tips within most peoples' means.

What the Government might do, if it wishes, is:

1. Set the agenda. One way is to create startling incentives for successful innovation. Tax concessions may be one way.
2. Try to uncouple investment in innovation from the City's need for short-term profits growth (see financial recommendations).
3. Strive to encourage, or help finance,"soft" loans from private institutions to manufacturers. These loans to be committed only to the WHOLE process of innovation.
4. Roll all its excellent, though particular, schemes which help bits of the innovation process into one large, bold, programme. (The DTI's awareness campaign for the Common market is a good example. Innovation is so central to Britain's prosperity that little less is called for now.)

5. Turn the Design Council into an INNOVATION COUNCIL; one which would bring together and promote ALL the elements necessary to successful innovation.
6. Encourage more "outward-bound", learning missions, providing their findings are publicised widely.
7. Encourage senior business schools to run courses for top managers on innovation; why it is essential, how to speed the process, how winners win. Help them to spread the messages throughout their companies.
8. Innovation, in any sphere, is a creative process. There is a need to show people in all disciplines that they are born creative and they can increase their imaginative ability. Show them how.

REFERENCES

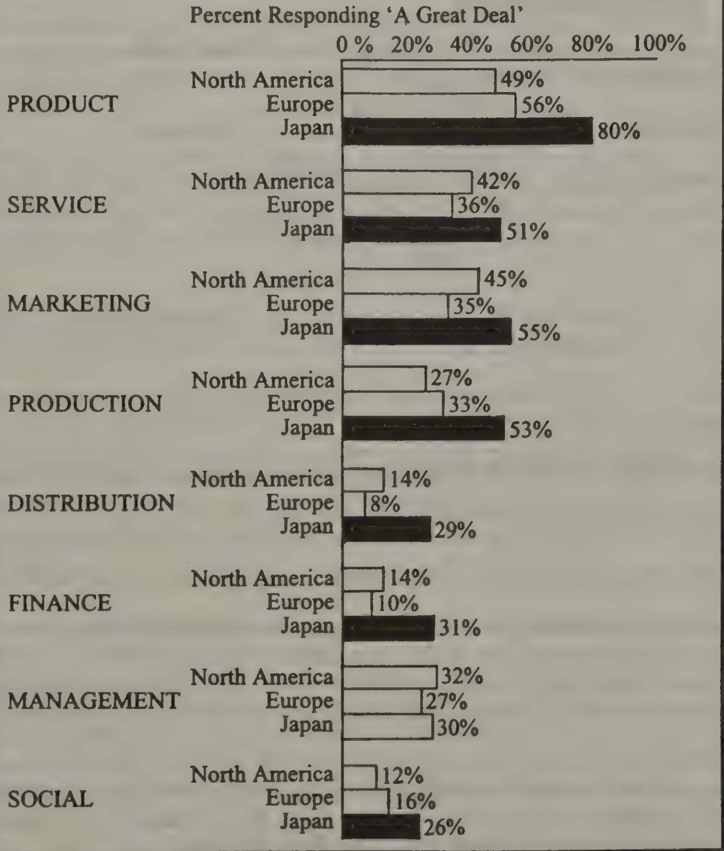
1. *Source:* Arthur D Little, study conducted mid-1985. A questionnaire was sent to top executives in North America, Europe and Japan. Japanese executives said innovation takes one-third of their time. European executives said 26 per cent, North Americans said 24 per cent.

2. Results of this international study suggest that competition, already fierce, will grow.

QUESTION 14

We at Arthur D. Little see innovation occurring in *at least* the following areas.
To what degree do you see innovation needing to occur in each area in your organization or core business?

Response: A Great Deal



Source: Arthur D. Little

3. Study tour organised by Design Council and PA Consultancy Group, 1986. Among companies visited: Sony, Seiko-Epson, Sharp, Matsushita, Minolta, Nissan, Brother, Yawasaki.

4. How UK companies find what customers want.

Use of market research techniques

	FMCG Per cent	Consumer durables Per cent	Repeat industrial Per cent	Capital industries Per cent
Company records	76.7	72.4	72.6	67.9
Survey of consumers	42.1	19.0	20.8	18.7
Survey of distributors	17.7	23.1	19.9	13.9
Qualitative research	39.0	19.9	19.1	22.0
Field experiments	25.0	17.1	17.4	12.0
Laboratory experiments	22.8	9.1	12.3	4.8

Source: Institute of Marketing, 1984.

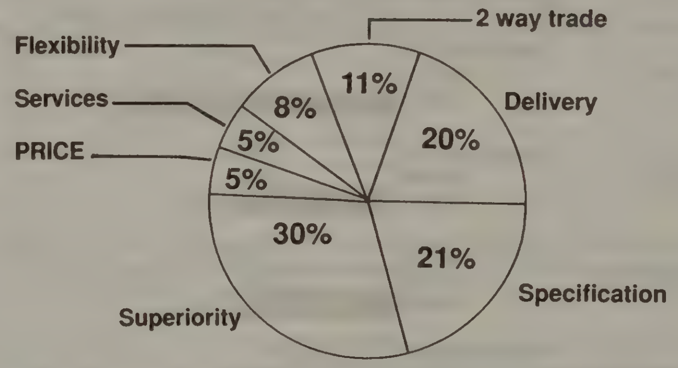
5. Mitch Madique, at Stanford University, studied 158 high-tech companies in Silicon Valley. Some, of course, performed better than others. What distinguished the winners? According to Madique "If you're a technologist, its easy to delude yourself into thinking that it's the gadgetry that makes the success. But looking back at the research I now realise that the key was that the product added value to the customer. It is not the technology that matters, but how you shape it for the customer".

6. From "Marketing Myopia", by Theodore Levitt, published in Harvard Business Review, 1960.

7. Source: (". . . you won't do it!"), report of a Pacific Basin Study Mission, prepared by the Department of Trade and Industry, 1985.

8. Design and the Economy, K Pick and K Schott, University College, London, 1983.

▲ **People buy better goods, not just the cheapest**



Source: Why UK machine tool industry choose foreign goods, NEDO 1963

9. See Double The Time You Give To Training in Winning Ways (James Pilditch) for horrifying figures.

10. A study conducted by MORI for PA Consultancy Group, in 1983, found three firms in four had no clear strategy about how they should use R&D. In another study, in 1984, PA found 19 per cent of chief executives thought technology had an impact on their business. This compares with 42 per cent in the United States and 44 per cent in Germany. Yet over half the British executive thought their products more advanced technologically.

11. NEDO commissioned research among British engineering-based manufacturing companies. Three hundred and three companies responded. The research was conducted by the British Institute of Management (by post) and Taylor Nelson Associates (by telephone).

One question was "which departments are involved *at the start of* a (new product development) project. The average of the total sample was:

> R&D—49 per cent. Sales—38 per cent. Manufacturing—39 per cent. Marketing—70 per cent. Financial Department—17 per cent. Design Department—38 per cent. Market Research—18 per cent. Technical R&D—33 per cent. Other—24 per cent.

Companies were then asked who was involved when the *final decisions* were made. Answers were:

R&D—40 per cent. Sales—48 per cent. Manufacturing—52 per cent. Marketing—64 per cent. Financial Department—30 per cent. Design Department—36 per cent. Market Research—15 per cent. Technical R&D—32 per cent. Other—34 per cent.

12. Colin New, Professor of Operations Management at Cranfield School of Management, conducted a study for the British Institute of Management. He looked at 250 manufacturing plants. Less than half the firms interviewed intend to put "high" or even "fairly high" emphasis on CAD or CAM. This dropped to one-quarter for FMS and 16 per cent for robotics.

13. During the NEDO project the author met 40 industrial designers. Most companies, they said, "have no budget for product design". How do you get paid? I asked. "Enterprising managers" they replied "wrinkle the money for other budgets".

14. Quality costs in the UK range from 5 per cent. to 25 per cent of turnover in most companies. That is the estimate of the University of Manchester, Institute of Science and Technology.

Edwin Whiting and Malcolm Walsh, of the Financial Control Research Institute, have said "in the short-term, any quality improvement will probably reduce productivity . . . In the long-term reduction of internal failures should increase the volume of quality assured product."

Anne Humberstone, secretary to the production Committee of the CBI, points out that the Japanese pursue quality before price. They believe, she said:

- Quality products will always sell best because good quality serves the customer best.
- Consistent quality actually leads to greater productivity, lower manufacturing cost—and therefore competitive prices.
- There is no conflict, in the end, between price and quality.

15. Manufacturing Resurgence. Reality or Myth? PA Consulting Group 1988.

16. Mike Burlington, head of manufacturing division of PE Consulting Services Ltd.

17. A story about the gap between engineering design and production: An eminent British designer was retained to design a range of products for a British firm. Things started well, then bogged down. The designer found the head of engineering design and the head of manufacturing wouldn't speak to each other. They hadn't discussed the work in hand. The designer had to use subterfuge to get the two men in the same room.

18. A British designer was retained to re-design ear defenders. The old product was made of several materials, with complex fittings. The designer showed how the same product could be made for less by clipping three bits of plastic together. Manufacturing people in the company rejected it. Within a year a Japanese company seized the market—with a product made from three bits of plastic which snapped together.

19. In the author's experience: consultant designers once recommended to a famous white-goods manufacturer two materials and three processes they had never heard of.

20. An anecdote: a very senior British product designer does four-fifths of his work, from London, for US and Japanese companies. Embarrassed by this imbalance, he resolved to give a year to marketing his services in Britain. In that time, he succeeded in meeting ONE managing director who discussed a new, specialised, computer he planned to launch. It was awkward: in Japan the designer had seen a far more advanced version of the same product. He told the managing director, who *did not believe him*. "In any event" said the managing director "they'll never come here, to our niche in the market". "They can and they are" replied the designer.

Memorandum by the Queen's University of Belfast

SUMMARY OF MAIN POINTS

The effectiveness of technology transfer from HEIs to industry:

- There is a great variety of ways in which technology transfer occurs and no universal best way. Companies need help and guidance to choose the most effective means in particular circumstances.
- Companies should be encouraged, in the first instance, to make contact with a university via its Industrial Liaison Office rather than with members of academic staff.
- Licensing is under-utilised by manufacturing industry, which seldom makes the first move to acquire new technology by this route from universities.
- Industry must realise that university development and patenting costs are significant factors when negotiating royalties and licensing agreements.
- Universities have consciously set out to try to understand industry's point of view. With honourable exceptions, industry has not reciprocated. This is particularly so when ownership and rights in intellectual property is at issue.

— Industry should not expect to own university intellectual property.

In response to the Sub-committee's invitation to provide written evidence, I wish to offer some views on aspects of the question "How effective are the mechanisms for technology transfer from HEIs, Research Councils and public laboratories to manufacturing industry?" My reply is confined to technology transfer from HEIs to industry and although drawing on the experiences of this University I have addressed this question in general terms, rather than specifically as it affects Queen's.

As well as the points enumerated below may I draw the Sub-committee's attention to an item entitled "Horses for Courses" which was published on page 11 of the 1989-90 Hobson's Directory "Higher Education Resources for Industry". That piece enlarges on some of the comments which follow.

1. The means by which HEIs, and universities in particular, transfer technology to industry include:
   - Licensing of Intellectual Property (IP) and know-how.
   - Consultancy.
   - Contract and collaborative R&D.
   - Industrial Clubs (often engaged in "pre-competitive" R&D).
   - Participation in R&D consortia under such as the LINK or EC R&D programmes.
   - Staff transfers and secondments to industry.
   - Provision of specialist courses, both open and bespoke, in new technology.
   - Teaching Company Schemes.
   - CAST (= CASE in GB) awards.
   - Specialised Industrial Units, many having staff employed solely on work for industry.
   - Equity sharing joint ventures and new company formation.

2. Given this variety there is no universal "best" way to transfer technology and companies often need help to choose the most effective and cost-effective route to adopt.

3. Not all HEIs offer such a diversity of services but virtually all UK universities now have a professionally staffed Industrial Liaison Office, Bureau, Unit or Company. These are variously named, at Queen's it is QUBIS, but in all cases their role is to provide a single point of first contact with the university, offer advice, make appropriate referrals to specialist services or expertise and make the necessary contractual arrangements for effective Technology Transfer.

4. Companies should be encouraged, in the first instance, to make contact with a university via its Industrial Liaison Office rather than directly with members of academic staff. Industrialists can then be assured, on the one hand that the university's policies and procedures are being correctly applied and on the other, that the researchers will be able to concentrate on the main task. The University Directors of Industrial Liaison (UDIL) publishes the contact names and telephone numbers for all the UK universities (and some in the Republic of Ireland) together with a list of the services available from each institution.

5. Licensing is, in our view, under-utilised by manufacturing industry. We have had a number of very effective technology transfer agreements for know-how as well as for patented IP with manufacturing companies but in every case the University has had to make the approach. It has been a time-consuming and often frustrating task trying to locate and interest companies in innovative technology. Occasionally we receive circulars from brokers and agents seeeking technology in various fields but direct approaches from companies are rare.

6. Another aspect of licensing from the university point of view, is that it can take years from the granting of a licence to a company to the build up, first of production and then of sales, to the point where significant royalties are received. During this time the university frequently is carrying patent and other costs. Industrial licensees seem not to appreciate that this prior investment, like their own R&D investments, has to be recovered and is a significant consideration when negotiating royalties.

7. There is no case for feeling complacent but the universities have done a great deal in recent years to be pro-active in the marketing of their services. Most have tried to understand the industrialists' points of view and differing perspectives. This has not been fully reciprocated by industry. It is not always appreciated for example that expertise in a topic takes many years to develop. Typically, the research leading to a centre of excellence will have been funded from a variety of sources, including perhaps Research Councils, Government and the private sector. It is not reasonable in these circumstances for a company which pays little more than the marginal costs of a piece of research to claim ownership or rights in the background information. This point is frequently misunderstood by industrialists who claim to have funded this or that piece of research.

8. Ownership, even of foreground rights, should not be assumed, especially if less than full costs have been charged by the university. Today's foreground knowledge becomes tomorrow's background know-how and since it is part of the *raison d'être* of a university continually to extend the boundaries of understanding, it must be free to build on all of its earlier research without having to seek permission from those who may in the past, have funded this or that part of it.

Should the Sub-committee require elaboration of any of these points or wish to have examples to use by way of illustration I will be glad to provide whatever is required. As you requested I also attach a single sheet summary of my main points.

Dr G S G BEVERIDGE
Vice-Chancellor
April 1990

Letter from Quo-Tec Ltd.

I am writing to submit written evidence to the Select Committee on Science and Technology Sub-Committee I—Innovation in Manufacturing Industry.

In October 1988, Quo-Tec were awarded a contract from NEDO to study best practice in UK-based manufacturing companies in the **management of innovation.** The purpose of the study was to develop a **Tool-Kit** to help other UK manufacturing companies to improve their management of innovation. The Tool-Kit will be launched in April/May of this year. Our major findings are listed on the enclosed sheets. I have also replied to the specific questions raised in your call for information.

I should be pleased to provide more details if you feel it would be helpful to your investigation.

N A WATERMAN
Chief executive
19 *February* 1990

Summary of findings of study of best practice in UK-based companies, by Quo-Tec Limited, October 1988–December 1989

MANAGEMENT OF INNOVATION IN UK MANUFACTURING INDUSTRY

1. Companies which are successful in managing innovation are first and foremost very well managed.

2. Innovation is as important to the day-to-day activities of a company as it is to the longer-term issues.

3. The management of innovation is a continuous process; it involves everyone in the company from the storeman to the chief executive.

4. The management of innovation may be taken to be synonymous with the management of change. In successful companies, the chief executive is dedicated to the successful management of change. He, or she, is rarely satisfied with current performance and is constantly striving for improvement.

5. The conversion of a company culture from stagnant to that which fosters innovation requires the introduction of relatively few new like-minded people. The majority of the workforce have latent potential for successful innovation which can be realised by the example of a few key personnel. Commitment of the chief executive to the successful management of change is essential.

6. Innovative companies are based on unique technologies which are protected by patent or special know-how. Awareness of competitors and **competitive** technologies are vital to their continued success.

7. Performance related pay schemes feature prominently in companies which manage innovation successfully.

8. Successful innovative UK-based manufacturing companies seek to be world market leaders in their chosen field and will not enter a new market unless they can see a route to becoming a major player in that market.

9. Customer concern dominates the thinking of successful UK manufacturing companies. This concern is felt by personnel at all levels in the company.

10. Company organisation is very important. It must be structured to nurture and provide rapid feedback on new ideas. It must be sufficiently flexible to allow the formulation of a task force to develop and launch new products. Such task forces have a limited life-span and membership dictated by the needs of the new product. The formation of a **permanent** new product department is counter-productive.

Answers to questions raised by Sub-Committee I based on findings of Quo-Tec/NEDO study of best practice in UK industry

Q1 *What are the effects of company attitudes and structures?*
Company attitudes and structures are vital. This is fully covered in the Tool-Kit for the Management of Innovation developed by Quo-Tec for NEDO.

Q2 *How active are UK companies in seeking out external technology, especially from overseas? How well do they adapt and apply it?*

Successful UK companies are very active. However, this is a major weakness in many UK companies and a barrier to future success.

Q3 *What are the respective roles played by product development and production engineering in technological innovation?*
New product development is a high priority. The very best companies are dedicated to making their current product range obsolete through their own successful technological innovation.

Q4 *How effective are the activities of Government departments in promoting and supporting innovation?*
DTI support for innovation has been effective in certain sectors. Some highly successful case histories, e.g., Keralloy development (novel glass-ceramic coated steel for improved electronic substrates and hotplates for domestic appliances) is a model for future support. [More details can be supplied on request].

Q5 *What are the effects of City attitudes to investment in innovation?*
Largely negative but improved communication from technologists to investors would ease current problems. Timescales for most technological developments are too long for City but that is not the City's fault!

Q6 *What is the effect of the legislative and regulatory framework concerning, for example, labour costs, patent laws and tax concessions on R&D and the purchase of know-how?*
Very great scope here for new legislation to stimulate better technology. With regard to other issues raised by the question, the UK must harmonise its approach with that of its main competitors, i.e., West Germany, France, Japan and the USA.

Q7 *How effective are the mechanisms for technology transfer from HEIs, Research Councils and public laboratories to manufacturing industry?*
There is common misconception here. In reality, there is **not** a large store of directly employable technology lying dormant in HEIs, Research Councils, etc., ready for "transfer" into industry. Most new products and processes are developed to meet a clear need and require typically more than 50 discrete inputs from HEIs etc., plus the experience based knowledge of the company and industry concerned. In brief, HEIs etc., may contribute a piece of the jigsaw but without the other pieces, or a clear understanding of the complete picture, their contribution is likely to be ineffective.

Q8 *Does the UK benefit sufficiently from EC support for innovation? How might it be improved?*
Innovative UK companies are already reaping these benefits. More UK companies could benefit if they established good relations with potential collaborative partners in other countries of the CEC.

Q9 *What are the effects of the varying relationships between companies and their suppliers?*
Very successful new products have been developed as the result of collaboration between companies, their suppliers **and** their customers. This collaborative development approach should be nurtured. Current DTI schemes encourage this and should be more widely and effectively publicised.

Q10 *What factors influence decisions to invest in innovation in the UK or overseas?*
(i) A successful track record from the potential innovator.
(ii) A clear market objective.
(iii) A detailed and realistic business plan.

Q11 *In the light of ACOST's report* ***Defence R&D: A National Resource,*** *and the Government's response, is there a satisfactory relationship between the defence and civil sectors?*
There is great scope for improvement here. Unfortunately, the Defence Technology Enterprise company started with a fallacious view of technology and the means of its transfer, the wrong people and the wrong direction. It is hoped that their mistakes will not deter other initiatives.

Letter from Dr D H Roberts, University College London

Thank you for your letter of 6 June 1990. I find that my answers to several of the questions you pose are given in a recent talk I gave, so I enclose a copy [not printed]. On the topics not specifically covered:

Question 1
The key decision is always that of appointing the right person to run an operation where innovation is sought. This may be self-evident, but it is the most important single factor and explains why we can find good and bad examples of innovation within the same Company, where the total environment (Company: City: Government: Educational System, etc.) is presumably the same. The right person will fight for investment, get it, and make it work.

Question 2
Probably not too active, and there may be some valid reasons for this, such as:
(i) Many sources of such technology come and sell their product in the UK market as competitors.
(ii) Shortage of technology is not the most common cause of poor innovation.

Question 3
See my paper, and comments on the Innovation Chain.

Question 4
Do they?

Question 5
Well known to run counter to long-term investments in research, manufacturing, or market development. Maybe the problem is created by manufacturing companies' pressure on their own pension fund managers.

Question 6
This has never seemed particularly important to me.

Question 7
In descending order of effectiveness:

- HEIs
- Research Council's (other than work funded in HEIs)
- Public Laboratories.

The reason is that *people* transfer technology, and people flow from HEIs into industry.

Question 8
No. Could be improved two ways:

(i) By giving the impression that the UK is a positive participant in EC programmes, not a permanent critic.

(ii) By having national policies and programmes which complement EC programmes—as do our competitors.

Question 9
Should be: Market and availability of necessary skilled personnel. Is too often the availability of financial subsidary.

Question 10
See my paper.

Dr D H ROBERTS
Provost
18 *June* 1990

Memorandum by the Royal Society of Chemistry

INTRODUCTION

The Royal Society of Chemistry (RSC) welcomes the opportunity to comment on some aspects of the study being undertaken by Sub-committee I. The RSC represents approximately 42,000 individual chemists and chemists employed in industry form its largest sub-grouping. It might be expected, therefore, that the Society regards innovation in the chemical and related industries to be of great importance, not only to chemistry but to the nation.

Our comments will be related to some of the questions raised in the letter from the Secretary to Sub-committee I, dated 27 February, and her numbering will be used.

Question 2: The Chemical (including pharmaceutical) industries in the UK are successful on an international basis. The industry has a consistent track record of achieving around a £2 billion surplus on its balance of trade. Since the industry is a genuinely international one, it has to be active in ensuring that the best available technology, irrespective of its source, is being used. Many UK chemical firms licence overseas technology and also offer their technology under licence to overseas companies. This two-way flow is an important factor—companies which have nothing to offer the international industry are unlikely to be chosen as licensees for major new technology from abroad.

Question 6: There can be little doubt that legislative and regulatory affairs greatly influence the decisions made in the R&D field. While it is true that at least the early stages of research can be carried out almost anywhere (and therefore might be expected to migrate to areas of low labour costs), it is the availability of the pool of scientific and engineering talent which is more important. It is in this sphere that the RSC is concerned to help to ensure that the flow of talented researchers in chemistry is maintained in the UK. It seems to us that if, because of a lack of support for basic, fundamental chemistry research in our Universities and Polytechnics, the supply of key people to the UK chemical industry becomes constricted, companies will be forced to do more of their research abroad. Apart from the loss of highly skilled jobs in the UK, this could ultimately lead to the UK industry no longer being at the forefront of international trade.

In respect of legislation in the areas of safety and the environment, the major need is for international harmonisation. Since the products of the chemical industry are traded all over the world, considerable distortions of the competitive position can arise if widely differing legislative positions are adopted. Although the impact is more obvious in the production sphere, it also has a potentially major impact on the innovation process.

Question 7: Within the field of chemistry, it is our belief that good contacts exist between industry and academe. Most Chemistry Departments in the HEIs have some direct industrial links in the form of consultancies, specifically sponsored research projects, CASE studentships, etc. Equally, most chemical companies which have any significant R&D effort are well aware of where the academic research in their particular field is being undertaken. Although it is frequently said that UK industry is slow to pick up ideas and developments coming from HEIs, Research Councils, etc., we doubt whether this is true as far as chemistry and related subjects such as chemical engineering and biotechnology are concerned.

J S GOW
April 1990

Letter from Professor J Saunders, Loughborough University

Thank you for the opportunity to provide evidence to the Select Committee. As you will realise, the literature and knowledge on innovation in manufacturing industry is massive, there being several major strands of research which range from the less useful studies from economics to the very valuable contributions from organisational behaviour, technological innovation and the diffusion of innovation. On undergraduate and postgraduate programmes, I have for years tried to integrate this material but have found it rather like nailing jelly to a tree. In providing evidence to the Sub-Committee I could write yet one more book on technological innovation, but instead will limit myself to comments on certain key issues which I think are particularly barriers within the UK. These I expand in the appendix to my letter and I also take the liberty of adding a couple of my own papers which develop some of these ideas (not printed). The aim is to give views from the breadth of my research and readings rather than irrefutable facts.

I would say the following are the critical dimensions which distinguish Britain's failure to manage innovation:

(1) Functional management training and organisation which mitigate against the lateral decision making processes which are fundamental to innovation.

(2) Low levels of professionalism across management and technology generally which mean that managers have difficulty understanding fields other than their own.

(3) The dependence of innovation on individual endeavour and hands-on management, both of which Britain tends to belittle.

(4) The dependence of innovation on the drive of an individual for fame or fortune or intensive team-work, both ideas which are often belittled by the British.

(5) The ability of capital and people to move quickly. This often depends on individual's wealth rather than the work of institutions and Government bodies.

(6) The predilection of the British towards thinking rather than doing and muddling through amateurishly rather than working hard and being professional.

(7) An emotional preference and a channelling of the best people in the country into those professions which stop things happening, i.e., the Civil Service and accountancy, rather than those which make things happen, i.e., sales, marketing, operations management and engineering.

To these can be added many more and I am sure you will receive others from your other contributors.

APPENDIX

1. FUNCTIONAL TRAINING AND ORGANISATION

It is almost expected that British organisations are structured around function and that people train for life to work in a particular function. Yet innovation requires that people work across these functional boundaries. Natural as this may seem in the UK, such a structure is rare within the world and is correlated with bad performance within British companies. It leads to demarcation problems, to a narrow focus in decision making and empire building, rather than empire breaking. It is within the very nature of our professional bodies and educational system that these barriers are built.

2. LOW LEVELS OF PROFESSIONALISM

It seems odd that the professional bodies that were to enhance the position of marketing, or accounting and engineering, have resulted in low levels of professionalism. But this they have. In many cases the only true professionals in a business are accountants and it is therefore not surprising that control should be the dominant function. Within the less developed disciplines, managers train in their single area. This emphasises the divisions cited in item 1 and often causes them to belittle the other functions. Particularly dangerous at present is the perception that there is need for a shift towards a marketing orientation, as if marketing itself is good enough to drive a company. The answer is that no specific discipline is adequate to drive a company; it is a balanced consideration of all issues. This means far more than the Management Charter Initiative, which tends to train people for the job but means training people beyond their initial role. When one considers that Britain is spending between a fifth and a tenth on management training compared to our competitor nations, and that we train fewer engineers and technologists than any other country we are competing with, it is hardly surprising that our minimal attempts to train our managers results in narrow training rather than the development of broad skills in depth.

3. INDIVIDUAL ENDEAVOUR AND HANDS-ON MANAGEMENT

It is interesting to note that the history of Britain's Industrial Revolution can almost be read without ever coming across the mention of our universities. True, these institutions did provide some understanding of the physical world, but seem to contribute little to those who were creating Britain's industrial empire. Strange as it may seem, industrial innovation is made of the same stuff as it was in Victorian times, that is individual endeavour and hands-on management. Basically, industrial ideas occur where the tyre meets the road, that is when the salesman meets the customer or the production person handles the materials from which products are formed. Innovation takes time and effort and unless there are signs of rewards to individuals making this effort in terms of money or recognition, there is little encouragement for the person taking the risks necessary. In Britain, even the word "nouveau riche" is almost an insult, therefore it is hardly surprising that people in Britain are not as hungry as their peers in Singapore or California to create personal wealth. It is unsurprising that, where the professions that are almost respected are those which are well away from customers and manufacturing, good industrial ideas hardly ever emerge.

4. SPURS TO INNOVATION

There are two basic models of industrial innovation. One is typified by California, where the drive is for individual fame and fortune; there the motivation is easy—money counts and is respected and people are willing to go for it. The second model is teamwork and a sense of belonging, which is used by the Japanese. This we tend to view cynically. Instead we prefer to view innovation as being the result of some mad, weird and wonderful scientist, who presumably does it for love rather than money. True, Britain has achieved a lot of Nobel prizes in this way, but Nobel prizes which have initiated ideas to be developed in America and commercialised by the Japanese. Basically, the British believe in three myths:

(i) The mad scientist who has great ideas.
(ii) The great break-through which will solve all ills.
(iii) The belief that Governments can manage this process more effectively than individuals.

5. MOVEMENT OF CAPITAL AND PEOPLE

Capital and people need to move about quickly. This means making it possible for people to leave firms easily and set up by themselves, and individuals with fortunes who can back ideas and give guidance. The British banking system fails in this, as it is hardly ever capable of giving the sort of advice which risk capitalists can provide in America. Here again, we have the division between the clean handed bankers and public sector employees on the one hand, and the grafters on the other. The two need to be closer to produce providers of capital seeking high returns in return for risk. It is difficult to imagine that it will ever be achieved without people having wealth to move around themselves. This is how the Industrial Revolution occurred, it is on what capitalism is based and it is the model upon which Silicon Valley developed. Maybe to allow this to happen, we must overcome the jealousy associated with seeing people with vast amounts of wealth, which they use to get even more wealthy.

6. ATTITUDES

When one asks managers what they want in Britain, one is often told they need more time to think. They often request more facilities and tend to surround themselves with the trappings of success, preferably in the City, well away from the dust and smoke of manufacturing. We have retained a quaint belief that we can think out solutions when in reality nearly all solutions require hands-on experience. Maybe our ability to get Nobel prizes in an indication of our desire to think great solutions, rather than to get things done. Balanced by this desire for the cerebral, is a preference for the amateur. We are perhaps unique in nations in perceiving amateurism as almost a good quality. Many of us exude pride in stating that we have achieved through flair rather than hard work. By this means we propagate a dangerous myth. It justifies our lack of training and deludes us into thinking that those who profess not to have tried actually have not tried. In reality, the truth is that most people are successful in innovation and business by working hard. But in Britain, working hard can be particularly rewarding. As an American colleague once said to me, "Working in Britain is great, because people don't try very hard and so it is easy to win."

7. Channelling our best away

Because we prefer the professions to business, and planning to doing, many of Britain's best brains are channelled into those areas which are likely to be unproductive from the point of view of manufacturing industry. Still having a high regard for recreational degrees, our best brains study at institutions which are non-technological and although entertaining provide little economic worth. Even business managers often profess that a well-rounded education is one which is preferable to a specialised one. Fine, but are there indications that the British have any great ability in surviving in markets where they do not understand the technology or the basic mechanisms of how businesses work? Our industrial record says not. If our competitor nations take seriously industry, manufacturing, technology and business, there is no reason why the British can survive without doing so. Yet even when those people turn their backs on the professions and enter business, one finds they prefer to study either finance, accounting or marketing. Even consulting is becoming an acceptable discipline, but never, never manufacturing or engineering.

JOHN SAUNDERS
National Westminster Bank
Professor of Marketing
4 *April* 1990

Letter from the Science and Engineering Research Council

Thank you for your invitation to offer written evidence to your Committee. Whilst we have views on all of the 11 points you list, we have restricted our response to those items that directly affect SERC's operation. For convenience I give our response against each of the points in order.

1. Company attitudes, in particular their attitude toward investment and personnel development, affect the way in which they work with universities. This varies widely from company to company. Some involve all levels of the company from managing director through to shop-floor technician interacting with universities and polytechnics. Others can be positively hostile towards any suggestion that working together with a university would be of benefit to them. We work with many of the former companies and find they not only welcome the interchange of ideas but enthusiastically take these forward. We would suggest that this is a key area of improving manufacturing effectiveness and for harnessing academic skills to work in partnership with industry. We believe research into the reasons behind these differing attitudes to determine ways in which they could be changed to the benefit of the country would be well worthwhile.

2. No comment.

3. The traditional British approach of separating product design development from production engineering has been one of the contributing factors in lengthening the time for new technological innovation to reach the marketplace. Both functions are crucial, but they must develop in parallel and be integrated as far as possible to minimise time to market. In some extreme cases the separation has had the effect of "double engineering" the product.

There is some evidence of an intellectual split between the two areas where product development departments have employed qualified engineers and scientists for many years and hence have a scientific ethos whereas production engineering has only recently attracted high calibre graduate engineers in any number. The recently intellectual boundary has often reinforced the physical boundaries that exist. This is expected to change in the next few years and it is essential that companies are aware of the potential benefits of such an integrated operation. Professor Bell from Loughborough University could be a useful witness to amplify this point.

4. We believe, naturally, that we are fully playing our part in ensuring that industry gets the benefit of new academic ideas and *vice versa*. It was for this reason that SERC established the Application of Computers in Manufacturing Engineering (ACME) Directorate in 1984 to encourage multi-disciplinary research in manufacturing engineering at universities with a heavy industrial involvement. The SERC has recently commissioned a review of the ACME Directorate and was encouraged to see in its conclusions that there is evidence of industrial companies taking up the ideas to produce products and processes that will improve their competitiveness. SERC intends to continue this work as it believes it is valuable underpinning for the manufacturing strength of the nation. We are however aware that we work with the more enlightened manufacturing industry and of the 143,000 manufacturing companies in the UK only one in 1,000 work with universities and it remains one of SERC's objectives to extend the coverage of its operation particularly to small- and medium-size companies.

The ACME Directorate holds regular reviews and presentations of its work. A common theme of feedback received during those reviews concerns a perceived gap in Government support. The ACME Directorate of SERC works well at the interface between academia and industry and the resulting research ideas can be taken forward using Teaching Company Scheme and DTI mechanisms. The next stage of product development often involves very substantial investment and it is often stated that there is a need for Government support in this area for example via tax concessions on R&D expenditure as happens in other countries. However this is an issue that lies largely outside SERC's general area of responsibility.

5. No comment.

6. No comment.

7. We believe that the mechanisms for technology transfer, either by the work of the ACME Directorate of SERC with industry direct and by technology transfer through the Teaching Company (jointly supported by DTI and SERC and other public bodies), are extremely effective and we have evidence to support this. Copies of the ACME and Teaching Company Reviews both instigated by SERC, could be made available to the Committee if they so wished.

8. The growing importance of CIM within Esprit and growth of certain parts of the Brite/Euram that relate to manufacturing, are clearly highly relevant to improving innovation in European manufacturing industry. SERC is not *directly* involved in these schemes but nevertheless endeavours to aid UK progress in the EC schemes through:

(i) Making UK academic groups aware of EC developments.
(ii) Influencing through UK representatives on programme committees the development of EC programme content.
(iii) Aiding, where possible, the UK academic groups to compete successfully in EC competitions.
(iv) Ensuring that, as far as possible, the EC and national activities are complementary rather than duplicative.

9. The closer relationship between piecepart suppliers and the main customers as evidenced by the changes in the motor industry are having significant effects on supply chain management and product development. All parties are beginning to see that they are mutually dependent on one another, and a better attitude of trust is developing. It is as yet too early to see the effect of this on new product development, but benefits from investment in manufacturing technology can clearly be seen in improved product quality and reduced design times. From an SERC perspective the benefits so far appear to have been restricted to the electronics and motor car industries. It is to be expected this will expand to other parts/assembler supply chains such as aerospace.

10. No comment.

11. We have no direct evidence of the relationship between defence and civil research in manufacturing being improved as a result of ACOST's report. It is noted there is a significant difference between the British approach and the US approach. DARPA is a major influence on manufacturing overall due to the American Department of Defence concern with both the end product and its method of manufacture and maintenance. The resultant improvements in manufacturing technology quickly work their way from defence through to civil in the US. It is considered that while our MoD continues to have little interest in manufacturing methods we are unlikely to see an improvement in this area.

In conclusion, I'd like to stress that as a Council partially responsible for funding the generation of new technology in the manufacturing field, we find ourselves in a supplier role and believe that many users should be involved in making a formal assessment. The disparate nature of British manufacturing industry will make this hard to achieve, but we believe it is essential.

PROFESSOR E W J MITCHELL, CBE, FRS
Chairman
6 *June* 1990

Memorandum by the Society of British Aerospace Companies Ltd.

The SBAC has considered the invitation from the Select Committee studying innovation to give written evidence, and is pleased to provide this Submission. It has been compiled from contributions from member companies, and is structured in accordance with the questions posed in the invitation.

Q1 *What are the effects of company attitudes and structures (including personnel policies, investment decisions)?*

In general, company attitudes are influenced largely by the search for competitive advantage in the marketplace. In the UK, often short-term strategies prevail because of the impact of results on the City; cf answer to 5. The industrial perception is that companies in the important competitive countries, for instance USA, Japan and other major states in Europe, enjoy more favourable climates for investments. Corporate structure and personnel policies are seen as important in cultivating innovation.

Q2 *How active are UK companies in seeking out external technology, especially from overseas? How well do they adapt and apply it?*

The ability of UK national companies in the aerospace industry to use international technology is inevitably restricted by the difficulty in obtaining appropriate export licences, particularly from countries with advanced technologies. On the other hand, licencing is not an alternative to innovation. Larger companies, in particular, require the strategic control of technologies and future development. In general, UK companies are relatively more conservative than those in the United States and Japan, although this cultural difference is reducing. Certainly in aerospace, the UK holds the lead position in Europe which markedly influences company activities in exploiting technology.

Q3 *What are the respective roles played by product development and production engineering in technological innovation?*

Although both elements are crucially important and inter-active, product development rather than production engineering is, by default, seen to be the main driver in technological innovation. This has to be corrected by the combined efforts of industry, the Education Institutions and the Government, to ensure that each element plays the proper role which would vary between different products. Surrounding this, process technology is becoming increasingly critical to innovation and therefore needs to be given appropriate consideration.

Q4 *How effective are the activities of Government departments in promoting and supporting innovation?*

DTI exhortation, while relatively inexpensive, is not really effective. Moreover, the recent demands and expectations by MOD, relating to securing the unrestricted rights to use intellectual property owned by companies, are inhibiting the furtherance of innovation in the UK. Overall, the lack of a Government industrial policy, beyond the belief in market forces, is harmful to the prospects for innovation in the manufacturing industry.

Q5 *What are the effects of City attitudes to investment in innovation?*

The City perception that R&D is a cost and not an investment is an important impediment to innovation; short-term results are all pervasive. It is vitally important that the City becomes more aware of industry and the opportunities that industry can provide for wealth creation.

Q6 *What is the effect of the legislative and regulatory framework concerning, for example, labour costs, patent laws and tax concessions on R&D and the purchase of know-how?*

The profitability of UK manufacturing is lower than that of our international competitors. Some countries, unlike UK, provide a positive discrimination in their legislative and regulatory framework and in their tax regime. Moreover, further disadvantage will be felt by UK manufacturing companies dedicated to innovation and R&D following the introduction of new concepts in the recent UK Copyright, Design and Patent Act. There needs to be a greater awareness of the relative crucial parts played by industry, the City and Government. A more sympathetic legislative regime towards industry and its wealth creating potential is the key to progress.

Q7 *How effective are the mechanisms for technology transfer from HEIs, Research Councils and public laboratories to manufacturing industry?*

The mechanisms for technology transfer are haphazard and not particularly effective, although recently there has been a greater awareness that the situation needs to be improved. Part of the difficulty has been the cultural difference between the natural instincts of people in the HEIs and those in industry. Whether, in the UK, the academic approach could be fully reconciled with commercial requirements of companies is debatable. If it were, such a transformation would not occur quickly.

Q8 *Does the UK benefit sufficiently from EC support for innovation? How might it be improved?*

It is premature to be assured of early UK benefits from EC support for innovation; there certainly is advantage in the ESPRIT and BRITE/EURAM programmes but mainly in the pre-competitive area. Parts of UK industry are not fully aware of the importance of R&D in the European context, nor the key role which UK industry could play. It would help if the Government were to create a more cohesive policy towards Europe and a realistic approach to the need to counter other European governments support for industries.

Q9 *What are the effects of the varying relationships between companies and their suppliers?*

It is not possible to generalise on the effects of the developing relationships between companies and their suppliers. However, there is a move towards a narrowing of the supplier base in favour of a more profound and long-lasting relationship with risk-sharing increasingly becoming more common.

Q10 *What factors influence decisions to invest in innovation in the UK or overseas?*

Clearly, the major factor is the perceived market advantage that would result from the investment. Other factors influencing decisions to invest in innovation in the UK or overseas depend very much on the country concerned and resulting tax breaks and grant opportunities; in the United States, for example, it is difficult for foreign companies to compete directly in the defence field without US based facilities. Further consideration includes the need to collaborate and the consequent work share and R&D decisions.

Q11 *In the light of ACOST's report Defence R&D: A National Resource, and the Government's response, is there a satisfactory relationship between the defence and civil sectors?*

In aerospace, the relationship between the Defence and Civil R&D sectors is very good, with a marked degree of cohesion; however, the belief that a reduced defence R&D contribution by MOD will be automatically adjusted by increases in the civil expenditure is flawed. Moreover, the MOD public stance that it has no remit to strengthen the UK industrial base will inexorably lead to a significant debilitation of that base and, inevitably, less choice for MOD in future years.

18 *April* 1990

Memorandum by the Society of Motor Manufacturers and Traders

SUMMARY

The motor industry in Great Britain, which is represented by the Society of Motor Manufacturers and Traders, is part of an international market which is affected by innovation.

Much of the evidence addresses this international situation where the industry based in this country has to maintain its competitive position against other countries where innovation is better recognised.

Q1 *What are the effects of company attitudes and structures (including personnel policies, investment decisions)?*
A. Company attitudes and structures can have a substantial effect on the application of innovation. There must be an acceptance by management of all levels that innovation is a tool to being profitable and competitive, especially in the long-term. There must be a vision for long-term benefit, sometimes over short-term profitability. Innovation has a major part to play in continually improving products and services to meet customer needs and this message must be disseminated from the top of the company.

However, there are presently in the UK very few large companies in the Manufacturing Sector which are purely British in scope of operation, financial control or location of manufacture. The number is decreasing continually as Industry becomes more global in its attitude—a change to be applauded.

As a result investment decisions are, by definition, taken in an international competitive environment. A number of key factors affecting such decisions would include personnel policies and the relative international fiscal issues and "cost of money". Trade Union activities which are fundamentally different in many of the competitive countries do play a large part in the formulation of individual company personnel policies and UK management often view with envy the Industry-wide systems prevalent abroad (the one-union syndrome) and can even see benefits in the two-tier legal structure operating for top management, existing in West Germany for example. This lack of consistency across Industry is felt to encourage a "leaf-frog" or "best-ball" approach to renumeration policies seldom to the benefit of Great Britain Ltd.

It is perhaps not within the scope of the study to dwell for too long on the financial matter touched upon earlier but it is, nevertheless, worth drawing attention to the relative costs of borrowing around the world, a severe burden for those of us who buy the machinery and systems necessary to maximise the innovation process at the UK's high interest rates.

Q2 *How active are UK companies in seeking out external technology, especially from overseas? How well do they adapt and apply it?*
A. The motor industry is multi-national in all aspects of Design Manufacturing and Component source. No Motor Company, no matter how small, can survice in a National vacuum thus external technology has to be obtained from all sources. Models design for worldwide production can sales are using external technology and innovation from many sources for both component supply and manufacture.

International companies will through their overseas affiliates have varying degrees of contact with for example, research institutes and universities abroad. Their industrial horizons will also be wider. It is probable that in this matter we have a large company/small company split and the task of encouraging the smaller entrants to join the game needs resolution. Most of the large, many of the medium and a few small companies in the UK already have industrial contacts with tertiary education in the UK and the two-way benefits are significant. Encouragement of personnel secondments should be high on the agenda for any action plan with special emphasis on those from educational establishments into Industry which are very limited in both scope and number at present. The three-stage career structure (period in Academia—period in Industry—period in Academia) which receives more support abroad should be considered though in the UK there do seem to be obstacles such as relative renumeration packages, perceived status and others which must be knocked down in practice.

The question of adapting external technology we believe depends on company size due to the apparently prohibitive "cost of entry" for many aspects. Again we may need to address the smaller company's needs since that is where the relative burden is greatest financially, considering the people investment as a financial burden.

Q3 *What are the respective roles played by product development and production engineering in technological innovation.*
A. Both have a part to play but they should not be considered as completely separate; they are both part of a continuing process and should not be considered in isolation. Innovative features may originate in the Development area and processing features in Manufacturing but each has to take account of the others part in the overall "production" process. Over the years, with increasing scale, timing and financial pressures Manufacturing Industry entered the "Development Phase" in which companies became compartmentalised and along the way product and manufacturing technology became separated. This is now recognised as retrograde and most companies are striving to bring the two activities back together. This process is generally referred to as "Simultaneous Engineering". This process has been assisted by the blossoming of Information Technology which has brought about the ability for advanced communication.

Q4 *How effective are the activities of Government Departments in promoting and supporting innovation?*
A. In trying to address this query one is inevitably up against a question of measurement. How can we measure effectiveness of Government policy and the activity of its permanent staff? The recent initiatives of the Department of Trade and Industry which have served to bring to the attention of management of the small operations and the population at large to the need for innovation have without doubt played a significant part, whether they were cost-effective in an absolute sense is problematic. We mentioned earlier (in Section 2) the question of status of Manufacturing Industry and of those who work in it. This image issue, which is by no means a new phenomenon, should be uppermost in any thinking associated with any future plan. We all know, at least those in Manufacturing Industry do, how exciting both mentally and technically can be the activities with which we are associated. Unfortunately we also know, and we are frequently reminded by the media, that the financial rewards are less than optimal. Industry has to some extent made progress on the renumeration front, perhaps Government could address the image issue more positively at all levels of "education" from schools to the public at large.

Q5 *What are the effects of City attitudes to investment in innovation?*
A. We touched on the financial investment differences around the world earlier. We do not believe the city in and of itself has a problem differentiating between the good and the bad investment on the larger stage. Where it does suffer in comparison with, for example, the United States is at the lower levels and it is often at this level that many of the small innovators operate, frequently on their own. There may well be a lack of knowledge of what is available for the smaller operations. Though many of the Enterprise Agencies are doing an outstanding job, the total coverage is inadequate on a UK-wide base.

Q6 *What is the effect of the legislative and regulatory framework concerning for example labour costs, patent laws and tax concessions on R&D and the purchase of know-how?*
A. We do not see any problems posed by this question as fundamental to the issue. This is not to say that encouragement of R&D by tax concessions would have a useful impact but it is not central to the problem. Legislative impact can, indeed, be seen as a positive influence on the adoption of innovation in industry since it is probably true to say that many developments only came about as a result of trying to meet increasingly stringent regulations. There are many examples in product areas such as vehicle emissions and noise and in the manufacturing area on health and safety which stand out.

However, restrictive "local" legislation and laws can have an adverse effect on companies working in a multi-national environment. Legislation must be international in outlook otherwise innovation, and hence creation, will go overseas. Legislation drafted as a political response to local pressure could rive manufacturers to only market innovative products overseas.

Q7 *How effective are the mechanisms for technology transfer from HEIs, Research Councils and public laboratories to manufacturing industry?*
A. The subject of this question is difficult to be precise about. We are sure that any external analysis of manufacturing industry participation with Research Councils, tertiary education, Trade Associations, Professional Institutions, etc., would indicate a high level of cross-pollination. Whether it is demonstrably effective or whether there is a better way of doing it are totally different questions. We believe that those who know about the existence of avenues of contact utilise them effectively. The information dissemination issue discussed earlier for the small organisation needs attention—we wonder how many benefit from Research Council funding for example?

Q8 *Does the UK benefit sufficiently from EC support for innovation? How might it be improved?*
A. The easy answer to this question is to say that support can never be sufficient. However, improvement can be made to any support by minimising bureaucratic controls and reporting mechanics. Also, budgets not affected by exchange rate fluctuations (a common European currency?) would facilitate accurate long-term forecasting and planning. Companies must also be able to compete on merit without local artificial restrictions.

Additionally we believe that insufficient is known of the potential for support in areas such as conferences/seminars for international information exchange, secondment of personnel on an international basis and dissemination of the results of the Community research for example. Perhaps such interchange of information can be encouraged by the Commission through Learned Societies.

Q9 *What are the effects of the varying relationships between companies and their suppliers?*
A. Initiatives taken by member companies on two aspects of this subject, namely the quantum leap in supplier quality and the development of international agreements with suppliers for components design/development/production in many differing locations have had a marked impact on the supply base for the Motor Industry around the world. The spread of such developments across the industrial boundaries both in the UK and elsewhere can only be beneficial. The demolishing of the traditional adversarial relationships between supplier and customer is fundamental to the success of the process and the benefits gained on both sides from stronger longer-term commitment most beneficial. Those suppliers that only produce parts without their own R&D will be at a disadvantage as they will not be expanding their innovative understanding.

Q10 *What factors influence decisions to invest in innovation in the UK or overseas?*

A. There are two factors which have critical influence on the choice of location for innovation investment. Firstly, the credibility of the technological development source, mainly associated with people expertise, and secondly, the financial implications. The former is self-explanatory, can only emerge with developing relationships over time and is thus a problem for the smaller operations. The latter again draws attention to the recurring cost of money aspect discussed earlier. An absolute requirement for any country to be considered as a prime choice is a general climate of economic and political stability.

Q11 *In the light of ACOST's report Defence R&D: A National Resource, and the Government's response, is there a satisfactory relationship between the defence and civil sectors?*

A. The Industry has only a limited interest in the defence field. There does, however, seem to be scope for increasing the cross-pollination between defence and other contracts/developments in the wide technology context. At present much of the useful transfer work appears to be in the instrumentation, process control or material development fields.

Memorandum from the TUC

I attach the TUC's response to the House of Lords Select Committee on Science and Technology Sub-committee on innovation in manufacturing industry.

The response draws heavily on the contribution of the Institution of Professionals, Managers and Specialists, which represents staff in the research institutions. The TUC would also like to add the following comments:

Question 6

The 1990 TUC Budget Submission called for increased capital allowances against corporation tax, which would apply to R&D expenditure as it would to other forms of investment. Prior to 1984 firms were allowed to offset 100 per cent of their spending on plant and machinery, against taxation immediately. However, since the 1984 tax reforms firms are only permitted to offset 25 per cent of their capital spending against taxation in the first year, with the remainder dealt with in subsequent years. By increasing the amount of capital spending that firms can offset against taxation in any one year the effective cost of capital would be less and it would help offset the adverse effects of high interest rates on investment. Although there is no general case for reducing corporate taxation given high profits, there is a case for an investment incentive given that there is the prospect of investment beginning to decline. A 40 per cent allowance may prove to be too costly, but there is a very strong case for increasing the 25 per cent figure.

Question 9

This question raises two issues. Firstly, customer/supplier relationships have been moving towards closer involvement, as part of just-in-time production strategies, and this can have varied effects. Sometimes, these can strengthen the role and contribution that suppliers can make, especially when they are based on single-sourcing of components, with the effect that they can encourage innovation. Sometimes, however, they can lead to a dependent relationship between suppliers and the companies who purchase their goods. This can particularly be the case with small suppliers, and where retailers, for example, dictate design and product specification. The essential thing, therefore, is that the relationship is based on partnership rather than the dominance of one company by another. Secondly, there is an international dimension. The concentration of design, R&D and product innovation at the overseas headquarters offices of multinational companies tends to lead them to source their high technology, core components from overseas suppliers, leaving UK firms to supply the generally lower technology parts associated with final assembly.

Question 11

The TUC has consistently argued that a disproportionate share of Government R&D has been devoted to defence applications, and has argued for better civil exploitation of defence research. The 1987 Memorandum to the NEDC on Innovation Policy, for example, said: "The TUC welcomes steps being taken by the Government and others to increase civil exploitation of defence R&D".

The TUC would welcome the opportunity to discuss these comments further in oral evidence.

Q1 *What are the effects of company attitudes and structures (including personnel policies, investment decisions)?*

Short-termism

(a) Short-termism is widely recognised as a major problem in the UK—inhibiting capital investment, investment in people and investment in R&D. It is not necessarily the fault of individual manufacturers, but fostered by the attitudes of institutional investors in The City. This feeds down to companies. Even in firms with good reputations for R&D like Amersham International, our members report that financial and time constraints place a pressure on researchers to take a "me-too" approach, copying or modifying other researchers' ideas, rather than being truly innovative.

(b) Even in the public sector, short-termism is coming to the fore. As the government encourages a more commercial attitude from its "firms", they are less able to undertake basic and strategic research which may (or may not) transfer to the productive economy in the future. The IPMS UK

Atomic Energy Authority branch report that stricter management of time has reduced the possibility of broad innovative and creative thought and replaced it with pressure to undertake particular pieces of work for customers.

Intellectual Property Rights

(c) In the view of the IPMS Patent Office branch, innovation by many UK industrial concerns, particularly small- and medium-sized enterprises, is inhibited by their lack of knowledge and use of patents and other forms of protection for intellectual property rights. This was a major theme of the 1986 White Paper *Intellectual Property and Innovation* (Cmnd 9712). The Patent Office is seeking to help rectify this problem and has recently piloted a seminar series—with the objective of convincing firms of the importance of intellectual property rights and their exploitation—targeted at small- and medium-sized firms in the North West. Full use of patent rights does not only maximise the returns from innovative activity, but also prevents duplication of effort. The Patent Office holds a wealth of technical information on what has been done before.

Personnel Management

(d) On personnel policies, the IPMS Amersham International Branch made the important point that companies need policies to retain and motivate high calibre scientists and technologists by ensuring there is a career for them without them having to become "managers". "Dual track" career structures, whereby active researchers can achieve equal status and salary to their management counterparts.

(e) Training is an obvious pre-requisite for the skills and confidence to innovate and promote new ideas.

Q2 *How active are UK companies in seeking out external technology, especially from overseas? How well do they adapt and apply it?*

(a) The Patent Office provides an advisory service which draws upon its patent collection and the expertise of its patent examiners to advise firms on the existence of important technical information in any area of technology. IPMS members working in this area have the impression that UK companies have much scope for improving their efforts to seek out external technology.

(b) If you want a success to report, Amersham International has been very active in using external technologies. It obtained sole rights to develop commercial brain scanning agents from an idea which originated in the US nuclear medicine research field. The resulting product—Ceretec—is now one of Amershams largest selling lines.

(c) However, excessive reliance on overseas technology can be harmful in the long run if it is allowed to suppress creativity in the UK. Japan has recognised this and is now establishing a strong basic science capability. The IPMS UKAEA branch feel this is exactly what has happened in the case of the government favouring US PWR reactor technology over the UK's AGR. Once the country has "opted out" of a particular area, it will be very difficult for it to opt back in.

Q3 *What are the respective roles played by product development and production engineering in technological innovation?*

(a) Amersham International's experience is probably representative of many manufacturing firms. Almost all innovation and product development occurs within the R&D units. Very little occurs in the production function, primarily because of the (short-term) emphasis on management by results.

Q4 *How effective are the activities of Government departments in promoting and supporting innovation?*

Background—the Government's R&D Policies

(a) On coming to power in 1979, as well as cutting R&D expenditure, the government encouraged the Universities, the Research Councils and its own laboratories/research establishments to become both more commercially minded in their own management and of more direct relevance to industry. In short, the government was asking for less "blue skies" work and more applied R&D. The various institutions obliged by moving rapidly towards "the market".

(b) Halfway through the '80s, this policy was not just changed, it was subject to a major U-turn. The government now saw its role as, not in "near market" research—which industry should pay for—but in strategic research, essentially the generation of knowledge (albeit in fields selected for their exploitability over the next 10 to 20 years). IPMS believes the general thrust of the new policy to be correct, although selectivity can go too far (especially in relation to opting back in, as discussed in 2) and there remains a need for adequate funding. However, this sudden and complete change left the various publicly funded R&D bodies high and dry, and with no time to adapt. The key research establishment for manufacturing industry—the National Engineering Laboratory—had struggled to make itself more market oriented and short-term in outlook and suddenly found itself being earmarked for privatisation.

Government Departments

(c) The future of the DTI is uncertain, but the Government's past record does not auger well. The market or sector Divisions are being disbanded and the scale of the DTI's operations wound down. Industrialists are, not surprisingly, dismayed by these decisions. As *The Engineer* magazine —a respected voice of that sector—commented on 1 March 1990:

> "Industry has a tough enough time from government anyway, without losing the one ministry that might be expected to understand it and help it. Abolition of, say, the agriculture ministry would be unthinkable; it ought to be the same with the DTI. But suddenly it isn't."

(d) The debacle surrounding the aborted attempt to privatise the National Engineering Laboratory shows Government's lack of understanding of its proper role in facilitating and supporting the private sector.

(e) The MOD is a major purchaser of high-tech products from the manufacturing industries and its purchasing decisions and policy are significant factors in companies R&D decisions. The effects of the MOD's procurement and R&D policies are discussed below in answer to Question 11. Suffice to say here that they have been damaging and the MOD should seek to support the defence sector in finding new products so it can adjust to the end of the Cold War.

(f) The effects of the Department of Energy's privatisation policy on nuclear R&D is discussed below in answer to Question 5.

(g) The IPMS Amersham International Branch answer to this question provides an apt summary: "Ineffective; no evidence of Government initiatives." And this, from a company which was once publicly owned and could be expected to know more about government assistance than most private sector organisations.

Q5 *What are the effects of City attitudes to investment in innovation?*

(a) As the City sees it, company profits dictate how much is invested in R&D. Short-term financial difficulties lead to cuts in longer-term R&D spending. The City needs to understand that R&D is long-term.

(b) Privatisation has resulted in areas where Britain has, in the past, taken a long-term view of R&D becoming very vulnerable. The best example of this is perhaps nuclear R&D, the need for which remains (greenhouse effect, etc.), but which electricity privatisation has all but destroyed.

(c) The "boom" in venture capitalists in the mid 1908s—heralded at the time as making an end to short-termism—was a false dawn. Many of them are now doing little more than property development and supporting management buy-outs.

(d) Whatever, the City's invisible earnings from currency speculation, fluctuating exchange rates discourage R&D. Uncertainty about future competitiveness in export markets discourages risk taking. Otherwise efficient and profiable firms can, if much of their output is exported, suffer greatly if the pound is too strong. When faced with reduced profits, R&D is one of the first areas for cuts in most firms.

Q6 *What is the effect of the legislative and regulatory framework concerning for example labour costs, patent laws and tax concessions on R&D and the purchase of know-how?*

Patent Law

(a) The patent system has a net facilitating effect on R&D. Without the protection afforded by patents, many companies would not invest in R&D. The association of patent rights with knowledge or know-how enhances the value of that knowledge, making its purchase—through licensing, etc.—worthwhile. Set against this, any "stifling" effect of patent law—where access to knowledge is denied to firms not prepared to pay for it—is of low significance.

Taxation

(b) It is undoubtedly the case that tax concessions on R&D activity would encourage firms to invest in innovation. Such a mechanism would also provide the government with a lever to encourage activity in strategic sectors of the economy. There are, of course, practical difficulties in this—it might provide a loophole for tax evasion for example—but the benefits would vastly outweigh any drawbacks. There is also a problem of definition—what is R&D?—the Select Committee's recent enquiry (report not yet published), *Definitions of R&D*, should help on this point.

Accountancy—the scourge of R&D

(c) The standard accounting practice on R&D, under which all but certain categories of expenditure have to be written off in the year they are incurred, is a significant disincentive to engage in R&D with only long-term pay-off potential. Deferred charging is only permitted where commercial success is reasonably certain and where expenditure is separately identifiable. R&D expenditure is as much an investment as capital expenditure and the ability to "capitalise" the former should be made more widely available.

Q7 *How effective are the mechanisms for technology transfer from HEIs, Research Councils and public laboratories to manufacturing industry?*

(a) Various technology transfer mechanisms used. Among the most important are:

- "Clubs"—where interested firms come together and jointly finance work in a research establishment, usually with some government support and have equal access to the technology.
- Licensing—where technologies under patent with a research establishment are made available for a fee or royalty.
- Contract work—self explanatory, but giving access to particular expertise or facilities at research establishment.
- Science parks—where proximity is supposed to breed contact. Not the success expected, except perhaps in small firms (often set up by University staff) developing technologies for the market.

(b) The British Technology Group (BTG) is recognised as the World's leading technology transfer organisation, and has a central role in promoting the adoption of technologies developed in the public sector by industrial concerns. It has not, however, found life easy under the DTI—its sponsoring government department—as directed by the current government, with its hostility to interventionist policies. It is also facing financial difficulties as many of its most profitable patents are about to expire. Finally, its future is overshadowed by the spectre of privatisation. Perhaps more damaging than the threat of privatisation itself, however, is the uncertainty surrounding BTG's future—the final decision by the DTI has been a long time coming. This uncertainty is hampering the Group's real business of "selling" public sector technologies to industry.

(c) The UKAEA has established AEA Technology as a separate business to sell the Authority's expertise to industry.

(d) "Clubs", etc., are useful, but it is doubtful whether they are a sufficiently interventionist mechanism. Government research establishments are not expert or aggressive in marketing their expertise. That said, they do try, and the real fault lies with British industry which is not sufficiently interested in innovation and drawing on what expertise is available.

(e) The government is plainly not particularly interested in any role as an "enabling state" when it comes to technology transfer. With the DTI's National Engineering Laboratory—a World-renowned research establishment with extensive links with industry—the government's idea of technology transfer is to privatise it. Yet, in the private sector, it would lose its independence—what companies would then trust it to keep their involvement secret?—and its government funding, it would be subject to short-term pressures and would probably not be viable.

Q8 *Does the UK benefit sufficiently from EC support for innovation? How might it be improved?*

(a) See evidence to Commons Education, Science and Arts Select Committee (attached).

Q10 *What factors influence decisions to invest in innovation in the UK or overseas?*

(a) A short list:

- Availability of skilled personnel—getting worse in UK.
- Availability of government support—getting worse in UK.
- Patent protection encourages investment in innovation.
- Restraints of trade/access to markets.

Q11 *In the light of ACOST's report* ***Defence R&D: a National Resource,*** *and the Government's response, is there a satisfactory relationship between defence and civil sectors?*

The lack of "Spin-off"

(a) It has long been recognised that the extent to which military technologies "spin off" into civil applications is low in comparison to the apparent wealth of opportunities. In this area, as in so many others, the UK has a worse record than our competitors.

(b) The failure of the UK to maximise spin-off has been seen as a problem in the past—put simply, it represents a waste of scientific and technical expertise which could be put to the nation's economic advantage. However, the need for improved spin-off takes on a special urgency if the defence sector is to survive through diversification into civil work. It represents the cheapest and least disruptive way of employing existing skills, knowledge and resources in non-defence work, whilst retaining those skills, knowledge and resources for the defence work that will inevitably continue to be required.

(c) We should not lose sight of the fact that "R&D" covers two closely related, but at the same time quite distinct, activities. Research activities are primarily aimed at expanding the knowledge base—providing an understanding of physical phenomena. Development activities, on the other hand, tend to be far more product specific—seeking to apply knowledge to achieve a specific objective. Obviously, research—which contributes to the nation's scientific and technological knowledge base—has greater spin-off potential than development.

(d) Out of the vast 1989-90 defence R&D budget of £2.35 billion, just £428 million, or 18 per cent, was spent on research. The remainder went on the cost of developing specific equipment and weapon systems. Research frequently produces an "enabling technology" which can have a number of applications—microelectronics is just one example of research which took place for the military but has proved to have wider application. On the other hand, civil applications of the knowledge gained in development work—artillery trials, for example—will not always be obvious.

(e) In 1989, the government's Advisory Council on Science and Technology (ACOST) addressed this failure in its report *Defence R&D: a National Resource*. ACOST found that:

- Less than 20 per cent of the MOD's research and development effort has spin-off potential.
- Much of this potential is unrealised.
- The UK is less successful than some other countries in bridging the military-civil divide, largely because it has inadequate institutional arrangements to encourage cross-fertilisation.

(f) ACOST put the blame for this firmly on the MOD and its refusal to take into account spin-off potential when assessing R&D projects:

"The encouragement of synergy between defence and civil sectors of industry is not recognised as a principal objective of MOD. It has no formal remit to identify that fraction of the defence R&D expenditure which possesses civil applicability and only a limited number of mechanisms are in place which aim to transfer defence technologies into the civil sector."

(g) As ACOST noted, this is in stark contrast to our economic competitors, whose governments have, as an objective, the gaining of wider benefits from their defence R&D expenditure. In other countries:

"Defence spending is recognised as a technology driver, and the relationship between defence and civil technologies is deliberately exploited both by government and industry."

(h) ACOST made a number of recommendations, many of which have increasing relevance with the need for the defence sector to diversify its activities. The Council's main point was:

"MOD should utilise its research and contractual procedures as well as developing its informed customer role in ways that take greater account of the nation's future technological capability, principally by encouraging investment in a broader national technology base for defence from which both defence and civil sectors may benefit."

(i) The measures needed to achieve this include:

- Greater participation with industry and other government departments in developing enabling technologies identified as having both military and civil applications.
- Restructuring the MOD research establishments so that the department's "enabling science" research is carried out within national centres of excellence serving both defence and civil markets.
- Awarding greater numbers of R&D contracts at the enabling phase to those organisations with proven technology transfer mechanisms;
- Formulation of R&D contracts in ways that positively stimulate civil exploitation of defence technologies.

(j) The Government's response to this report was not heartening. Although it agreed with the report's main objectives—effective provision of defence technology with optimum cross fertilisation between military and civil sectors—the Government felt this was best achieved "through the operation of market forces in an environment of competition, with carefully targeted public support at the pre-competitive stage". Of course, this ignores the well documented failure of *laissez faire* policies to deliver technological development.

(k) In the Government's view, the MOD has no role in wider science and technology policy, nor should it seek to have such a role. The inconsistency between the Government's objectives and its ideology is demonstrated in this startling non-sequitur from its response to ACOST:

"The Government does not see the Defence Budget as having an industrial sponsorship role or a responsibility for technologies unrelated to defence needs; that would lead to muddled roles and inefficiency . . .

"The Government agrees that rigid segregation of defence from civil research is in principle undesirable, and wishes to see the benefits of cross-fertilisation especially in enabling technologies."

(l) The problem with this is that ACOST found that cross-fertilisation, or technology transfer—is best achieved where both military and civil R&D take place within single organisations. Yet, the rigid separation of government funds and research establishments prevents this from happening. Similarly, in the private sector, suppliers are generally either purely defence suppliers or have quite separate and distinct "defence" divisions. This is in large part due to MOD conditions on secrecy and the old "cost-plus" procurement regime. Now that joint military and civil R&D teams are required, the Government is refusing to assist firms to adapt and is maintaining the demarcation in its own organisation.

(m) Some efforts to improve spin-off have been made, however. Following an equally critical report by Sir Iuean Maddock for NEDO in 1983—on spin-off in electronics—then Defence Secretary Michael Heseltine established Defence Technology Enterprises (DTE) in 1986 to identify MOD research projects with spin-off potential. DTE—a private company with MOD support—has been quite successful, but remains very small. The currently 30-strong company rents space at

MOD Research Establishments and has access to non-classified research that can be patented. If non-military applications are identified, the technology is then licensed by DTE to any firms or firms which wish to develop it.

(n) DTE has been a success—albeit on a small scale so far. It has 500 technologies on its books, and 60 licence agreements. Its income is currently £2 million, half from members' fees (subscribing companies who have access to the technology "portfolio") and half from licence fees. It is growing, but the need for this sort of transfer mechanism has taken on a new urgency. So, how can DTE grow faster and have a wider impact?

(o) A DTE executive has been reported as saying:

"We are frustrated at the moment that out size means we are not doing justice to the technologies that are available in the MOD. And most of them are enabling technologies." (Graham Thomas, *The Engineer* 18 January 1990).

Clearly, some additional finance—both from the company's shareholders (which include banks and the DTI's British Technology Group) and from the MOD—is required to assist expansion so as to increase the pace of transfer.

(p) A further problem faced by DTE is the fact that the MOD's share of royalties goes into central MOD coffers, rather than to the Research Establishment which was the source of the technology. Direct payment of royalties to Research Establishments would act as a considerable incentive to them to identify and develop commercial applications of their research for the civil sector and feed them into DTE.

(q) ACOST criticised DTE for concentrating on direct technology transfer rather than the cross-fertilisation of personnel—for ACOST, a more effective way of encouraging spin-off. There are signs that this too is changing. DTE recently set up a Laser Dynamics Division. However, this was the result of the personal initiative of a team from the Royal Signals and Radar Establishment who left RSRE to exploit their own work. Whilst beneficial to the wider economy, such a radical cross-fertilisation of personnel cannot help MOD. Secondment and the establishment of research teams drawn from both public and private sector would seem more preferable mechanisms.

(r) Overall, in the changed Europe of the 1990s, MOD should focus its R&D spending on enabling technologies, develop evaluation systems to assess the degree of cross-fertilisation achieved, and —as a minimum—give the DTE greater resources to encourage spin-off. The programme to assist suppliers diversify should be co-ordinated by a Diversification Agency within MOD. After years of encouraging suppliers to rely on MOD, it is the least the Government can do to help.

Procurement Policy

(s) It is not simply in the area of the government's own R&D effort that there are problems. The MOD's procurement policy, which defines its relationship with suppliers also inhibits innovation.

(t) With the appointment of Peter Levene as the head of the MOD's Procurement Executive, Government policy changed from paying suppliers on a "cost plus" basis to competitive tendering and fixed price contracts.

(u) The Government claims that increased competition and devolution of risk to suppliers acts to drive technological advance. No other NATO member claims this. Confronted with excessive risk, UK manufacturers inevitably adopt a short-term view. Prompted by The City, suppliers have to seek rapid returns on investment in R&D.

(v) ACOST, in its report on defence R&D, recognised these questions surrounding the MOD's procurement policy as it effects R&D:

"Some UK defence contractors have questioned the effectiveness of the current procurement policy, suggesting it is a short horizon strategy, over-ridingly aimed at cost reduction and with an inadequate emphasis on investment in, and co-ordination of, strategic and generic research. MOD's seemingly indifferent stance towards the long-term health of the UK's industrial and technological base has, therefore, been viewed as potentially prejudicing the ability of industry to satisfy long-term UK defence needs and to compete in the future international defence procurement market." (para 6.11)

In other words, not only is the procurement policy potentially damaging to suppliers, but it carries long-term risks for the security and quality of defence equipment.

(w) A recent report by stockbroker Hoare Govett entitled *Under Siege: European Defence in the Nineties* (reported in *Jane's Defence Weekly* 10 March 1990) is critical of the policy of competitive defence procurement. Whilst firms enjoying the larger markets and production runs in the USA can justify the financial risks involved in competing for a contract through its development phase, Hoare Govett question whether the size of MOD contracts can sustain a similar strategy in the UK. The report identifies two serious problems in particular:

- UK firms are being exposed to foreign competition while no compensating reciprocation has been established;
- intellectual property rights are such that companies' privately funded R&D information has to be surrendered to the Ministry as part of any ensuing MOD development contract.

Paper by The Institution of Professionals, Managers and Specialists

SCIENCE POLICY AND THE EUROPEAN DIMENSION
NOVEMBER 1989

SUMMARY AND MAIN CONCLUSIONS

1. The Institution of Professionals, Managers and Specialists, which represents scientific staff engaged in public research and development, is concerned that the ability of scientists within the Research Councils and other government-funded research bodies to maximise the opportunities afforded by European Community research and development programmes is being severely circumscribed by a number of factors.

2. These include:
- Reduced Government support for science—particularly relative to our major EC competitors—resulting in sub-standard equipment and the loss of qualified staff.
- The application by the Government of "attribution" and "non-additionality" in certain areas, both acting as disincentives to European involvement.
- The excessive use of short-term appointments for scientific staff.
- The inevitable, but daunting, bureaucracy of the European Commission.
- The partial failure of UK organisations to assist scientists to overcome this bureaucracy and make successful bids for funding.

3. If the UK's Research Councils are to improve their level of participation in EC programmes, the following action is required:
- Increased Government funding of civil R&D.
- The non-extension of attribution and non-additionality practices to the Research Councils and higher education institutions, and their abolition in other areas.
- Much reduced use of short-term appointments for scientific staff, and longer-term action to reverse the contraction of the scientific community.
- A higher priority to be given to EC involvement by the Research Councils.
- The development of an improved system for the dissemination of information on available funds and the formulation of proposals to scientists.

INTRODUCTION

1. The Institution of Professionals, Managers and Specialists (IPMS) is the trade union which represents 90,000 scientific, technical and specialist staff in the Civil Service, related public organisations and an increasing number of private sector companies. Over 4,000 of our members work in the Research Councils and, in compiling this evidence, we have drawn on their experiences of participation in projects funded by the Commission of the European Communities (CEC) and their opinions on how the level and quality of this participation might be improved.

2. As the Institution is not in a position to forward informed comment on some of the broader questions to be examined by the Committee (the EC role *vis-a-vis* that of Member States and the appropriateness of individual programmes, for example), our evidence will concentrate on our members' observations—the views of active researchers, rather than Research Council managers. In this way, we would hope to give the Committee an insight into the experiences of those looking at the process "from the coal-face".

3. Our evidence is, to some extent, based on two simple premises: that, on balance, UK membership of the European Community (EC) is beneficial; and that the EC is increasingly becoming a major source of research funds and UK research establishments should attempt to maximise this country's "share" of those funds. Even where there is a view that a given programme is mis-directed, maximum UK involvement means maximum influence over future developments.

4. Our evidence is structured as follows:
- A brief look at trends in civil R&D in the UK and abroad. Here, the basic question is whether or not the last decade's run-down of the UK's public R&D effort is now prejudicing our ability to participate fully in the European effort.
- A discussion of the pros and cons—from the point of view of the active researcher—of being involved in EC programmes.
- A look at some of the criticisms of the CEC bureaucracy in Brussels—again seen from the position of active researchers—and the support the Research Councils and the Government provide to help people deal with it.
- An examination of some of the apparent failings of the Research Councils in providing sufficient encouragement, information and support to scientists who do or might like to submit proposals to the CEC.
- A look at the key questions that we would like the Committee to ask the Research Councils and their masters in the Department of Education and Science, presented in the positive form of an agenda for action in improving the UK's share of the European scientific effort.

Civil R&D in the UK and abroad

5. Throughout the 1980s, civil R&D has been consistently cut back by the government. Although government R&D spending has broadly kept pace with inflation, it has been cut in real terms when the higher inflation rates for scientific costs are taken into account. The high rates of economic growth experienced in the latter half of the decade have not benefited science; its share of gross domestic product has actually declined—a quite remarkable trend in an advanced economy. Similarly, the proportion of government expenditure allocated to science and other R&D efforts has fallen over this period from 3.3 per cent in 1981 to 2.8 per cent in 1989. The Government's latest Review of R&D suggests that, far from being reversed, this decline is to be intensified.

6. These cuts have been traumatic for the Universities and the Research Councils. Of the Councils in which IPMS has a direct interest, the loss of staff will accelerate in the next few years. Between now and 1992, AFRC is projected to lose 750 (19 per cent) of its 4,000 staff, 240 of them graduates (this comes on top of the 24 per cent loss since 1986); NERC will lose 300 (12 per cent) of its 2,500 staff, including 150 graduates; and SERC will lose 60 (2 per cent) of its 2,700 staff, 24 of them graduates.

7. The problems that this decline in the overall numbers of active researchers presents are compounded by the increasing use of short-term appointments (STAs). This practice—where staff spend the first year of their appointment getting to know the subject and their colleagues, the second year doing research and the third looking for their next appointment—prohibits the development of stable and effective research teams. The efficacy of such widespread use of STAs was questioned by the House of Lords' Science and Technology Committee in their recent report on Agricultural and Food Research.

8. When the reductions in opportunities for scientists are taken together with this increasing use of STAs and the relatively low pay of scientists (highlighted by the Science and Technology Committee's recent Report on Civil R&D), it is not surprising that young people are increasingly turning their backs on a scientific career.

9. The general deterioration in the infrastructure of the Research Councils and Universities has been another result of the cuts. In its recent report "Science and Public Expenditure 1989", the ABRC drew attention to the desperate need for re-equipment. Total equipment needs amount to a cost of some £460 million (ABRC, para 54), and the Board said:

> ". . . these results suggest that the UK is not as well provided for as some other advanced countries, with worrying implications for our international competitiveness in research and scientific training."

10. The latest OECD Science and Technology Indicators Report confirms this view with disturbing evidence of the UK's relative decline in the international R&D league table. In the first half of the decade, we were the only OECD country in which the percentage of GDP devoted to R&D declined. Whilst the UK remains in the big league of R&D spenders, we are rapidly being caught up by others.

11. Taking total R&D expenditure as a proportion of gross domestic product (GDP), France caught up the UK in 1987 with 2.3 per cent and is on its way to a target of 3 per cent. Even Member States without our history of R&D effort are increasing their investment—Spain being second in the OECD league table of R&D growth, the UK bottom. Removing defence R&D from the picture, the OECD found the clearest decline in government spending on civil R&D to be in the UK. We have thus been overtaken by other countries in this sphere—Italy's government-funded civil R&D is now greater as a percentage of gross domestic product than the UK's. In its advice to the Government referred to earlier, the ABRC suggested that the UK is spending between £150 million and £200 million a year less on academic and related research than our main European competitors.

12. The UK currently secures a greater share of CEC research funds than it contributes. Whilst we acknowledge and applaud this fact, in the opinion of the Institution this is to be expected in view of the UK's historically high level of scientific endeavour. Our concern is that this eminence may be short-lived. It is inevitable that the Government's attitude to R&D, as exhibited by the above, must seriously undermine the efforts of individual researchers to secure CEC funding for their work. A research community starved of funds, inadequately equipped and short of qualified scientists is unlikely to continue to be attractive to the project proposal assessors in Brussels.

13. It is not just the overall level of funding which hampers UK involvement. The Government employs two accounting practices which act as a disincentive to UK involvement in CEC programmes. Under "attribution", Government contributions to EC expenditure are set against the budgets of one or more responsible Departments. Under "non-additionality", any "excess" income that a Department or public body derives from participation in CEC schemes is clawed back by the Government. At present, the Research Councils and Higher Education Institutions are exempted from the latter, more obvious disincentive. However, this could change if CEC R&D programmes start to focus more on the "basic" end of the research spectrum.

14. The Government's science policy prejudices UK research establishments in another way—concerning the manner in which CEC projects are structured. CEC programmes frequently involve the

"matching" of funds, where it is expected that the cost of a proposal will be shared by the CEC, the research contractor and at least one third party—ideally industrial, but possibly government. Because UK industry is notoriously bad at financing external R&D, our researchers find that, in the absence of government support, there is generally no third party funding available.

15. Finally, and going beyond the immediate concern here with the UK's performance in winning CEC research grants, the above raises fundamental questions about the ability of UK research bodies to compete with their EC counterparts for public R&D contracts in general. Under the public procurement directives being drawn up by the Commission in the run-up to 1992, all government procurement of goods and services will be open to Europe-wide competition. Thus, UK contracts will be open to tenders from non-UK laboratories and institutes and other countries' projects will be open to bids from UK establishments. However, the ability of our researchers—hampered by poor infrastructure, out of date equipment and transient scientific staff—to bid successfully for contracts must be in doubt.

WHY BE INVOLVED IN EUROPEAN RESEARCH?

16. There are obvious advantages to the UK from being involved in European R&D. Involvement offers influence over the direction of research programmes, prestige, the pooling of scientific resources and expertise and, of course, money. But what does such involvement offer the individual?

17. There would appear to be two extreme views of the utility of European involvement to the scientist as an individual. First, there are some scientists who enjoy travelling to endless workshops and being known in international circles. To others, the round of writing proposals, attending meetings and writing lengthy reports can relegate their scientific work to a minor activity. Although the views of most lie between these extremes, there is a tendency towards the latter, which is particularly keenly felt where cuts have left teams so understaffed that much of the practical work is done by the leading scientist.

18. That said, all are certain that there is great scientific benefit to be gained from participation in European and other international efforts. In particular, CEC programmes are seen as attractive, being—in the words of one of our members—"more inspired than most we see in the UK". The international objectives of the programmes means they are frequently breaking new ground and the wider contacts and new insights gained from meeting researchers from other Member Countries benefit UK scientists in a number of ways.

19. So, it would appear that, in addition to the resource problems discussed earlier, there are two main areas where scientists in some of the Research Councils feel disadvantaged in seeking European involvement: the bureaucracy of the CEC and the support they receive from the Government in general and their employers in particular.

THE CEC BUREAUCRACY AND THE BIDDING PROCESS

20. The "red tape" of the CEC has now passed into folklore and the size and complexity of the Directorates of Research makes a certain amount of bureaucracy inevitable. Thus, gaining a grant involves getting to know the system: when and where to apply, which topics are flavour of the year, who is in charge of the programme and whether the scale of the project is right.

21. The EEC Research Allocations Committee gives different sums of money for different sectors of research. Those putting proposals together for a given programme know the total sum available but not what might be allotted to its different elements. It is thus a matter of judgment whether to make a small bid or attempt to "scoop the pool". Added to this is the problem of finding one or more Continental bodies and/or industrial companies as partners so as to increase the chances of the bid being successful.

22. The formal procedures associated with funding applications are daunting and the failure rate is apparently high. The first hurdle, however, is one of the Research Councils' making, as they do not always allow bids to go forward. Of course, some sort of vetting procedure is vital to prevent frivolous or poor quality proposals from being submitted. Nevertheless some scientists have a suspicion that these decisions can be made for tactical reasons. These suspicions could be allayed and much time saved if the criteria controlling the Research Councils' decisions were clarified.

23. This uncertainty about the criteria by which projects are evaluated extends to the CEC's own evaluations. Researchers complain of apparently unwritten criteria of which their overseas counterparts are aware, but they are not. Although proposals are officially assessed on their scientific merits, there is a suspicion that the CEC might switch from one contractor to another for each stage of a programme in an attempt to spread the funds more evenly between countries. Such a scenario is not unlikely given the political pressures in Brussels.

THE RESEARCH COUNCILS AND EUROPEAN R&D

24. It is not our intention to review here the success rates of the different Research Councils in winning CEC funds. We do not have access to complete information and the Councils themselves are in a better position to provide the Committee with this. Instead, we would like to present the views of some of the Institution's members in the Research Councils who have been actively involved in trying to secure and then carry out EC funded work. In particular, we concentrate here on the apparent failure of certain Councils too provide sufficient encouragement, information and material support to their researchers in this respect.

25. Whatever the efforts of UK institutions, they can only be truly assessed in comparison with those of their counterparts in other Member States. Some researchers expressed a concern that their Research Council is not perceived as a "natural partner" by its counterparts in Europe. Within AFRC, for instance —a body which holds up its agreement with France's INRA (Institut National de la Recherche Agronomique) as an example of bilateral links—scientists cite the unwillingness of INRA to involve AFRC Institutes in its projects as evidence of its low opinion of AFRC. The AFRC's efforts are summarised in this statement from one of our members: their "approach to Europe is, in general, amateurish, second-rate and pathetic in comparison with other EEC countries". A similar level of disillusionment was expressed about the NERC. The SERC, on the other hand, appears to be considerably more effective, both in building international links and in supporting its researchers with information and in bids.

26. There is an obvious need for the Research Councils to actively publicise themselves within Europe and to build on the links that exist. Incidentally, this might also go some way towards mitigating the ill-feeling and mistrust engendered by the Prime Minister's somewhat jaundiced view of the EC's value.

27. One of the major forms of publicity and assistance to researchers provided by the Research Councils is a joint office in Brussels, until recently run by the NERC. Its main function is to ensure that UK scientists are made fully aware of opportunities to bid in good time. It produces a regular bulletin containing news of the latest developments in Brussels, details of proposed and agreed programmes, closing dates and budgets. Those scientists who have had contact with the office have found it "user friendly". Also, its facilities—in the form of meeting rooms, etc., are seen as highly valuable. However, researchers in AFRC and NERC feel that this is the limit of their Councils' active (and funded) commitment.

28. With the possible exception of the SERC, at the level of the individual Research Councils, the support system appears to be little more than a "mail box". Within AFRC, this was put down to the control exerted by MAFF, which regards EEC matters as "political" and is therefore reluctant to explain the workings of the CEC or to pass on even basic information such as how projects are evaluated. MAFF also appears to be reluctant to appoint non-MAFF people as expert assessors. As such, individual researchers are left to draw up proposals without being able to draw on an organisational "learning curve".

29. Even more fundamentally, the AFRC and NERC secretariats—which our researchers feel should be assisting bids—frequently appear unaware of programmes and deadlines and unable to provide advice. There would appear to be a lack of any co-ordinated effort on the part of the central offices to draw attention to potential opportunities upon the announcement of new programmes. Such support need not be a drain on scarce resources—all that is required is a team of two or three people acting as a point of contact between the Councils, their laboratories and Institutes and Brussels. Once again, SERC would appear to have considerably more sophisticated and better resourced support systems.

30. It would appear that, rather than generally encouraging staff to make applications to projects within their specialism, a Research Council makes a decision to bid when it feels it has to be part of a programme. In other words, choices about the extent and depth of our involvement are being made in a highly selective way, and a way which may have more to do with the prestige of the Research Council than science.

31. In some cases, scientists who are keen to participate in CEC programmes are forced to prepare proposals in their spare time.

32. On the question of the guidance and advice given to researchers drawing up proposals, the lack of clear policies on financial costs—marginal costings, etc.—have led to delays in the completion of applications. Even advice on things as basic as the appropriate signatories to an application appears to be unforthcoming.

33. On a less formal level, seminars and workshops have an obvious role in enabling staff experienced in certain areas of Europe to pass on useful information to their colleagues. This would also provide a route by which the Research Councils themselves obtain regular feedback. SERC has run a few seminars, as has the Brussels office.

34. At the level of the individual Institute and Research Station, the degree of support offered to scientists is highly variable and appears to depend largely on the attitudes of Directors and the individuals appointed as EEC Representatives. Of course, these attitudes are conditioned by the individuals' workload in other areas of their work, and it would appear rare that sufficient time is allowed for EEC work. It is also questionable whether the Representatives have sufficient organisational influence to give priority to EEC-related efforts.

35. The competition which often exists between Institutes and even between Research Stations within Institutes is ultimately destructive. A result of the climate of cutbacks, this competition is preventing the formation of co-ordinated proposals involving scientists drawn from different areas.

36. All in all, the Institutions's members wish to see a less ambivalent role being adopted by their Research Councils. Senior managers and Directors of Institutes and Laboratories should be left in no doubt that participation in CEC programmes is mandatory and that financial and administrative resources should be made available for those involved in CEC applications.

IMPROVING UK PARTICIPATION—AN AGENDA

37. The Institution feels that these observations from scientists active in attempting to secure CEC contracts suggest that the Research Councils are failing to maximise the opportunities afforded by the expansion of European R&D activity. The weaknesses we have identified suggest action is required in the following areas:

- *Government funding*—this needs to be increased, particularly for re-equipment but also to raise the morale of the scientific community and release researchers from excessive workloads. The target should be to match the levels of civil R&D funding (as a proportion of GDP) of our major EC competitors—i.e., France, Italy and the Federal Republic of Germany.
- *Accounting practices*—the application of "attribution" and "non-additionality" should preferably be abolished and, at least not extended to the Research Councils and higher education institutions.
- *Scientific staffing*—it is urgent that the present over-reliance on STAs is ended: it is an inefficient use of highly qualified people and, ultimately, deters young people from entering the profession. In the longer term, action on pay, education and training is required to resolve recruitment and retention problems.
- *Priorities*—it appears that some Research Councils give insufficient priority to involvement in CEC programmes. Their ambiguous attitude is reflected in the uncertainty scientists seem to have as to whether their individual efforts will be welcomed and in the lack of support the Councils give them in their bids for funding.
- *Information*—a centralised and well resourced system for the dissemination of information within each Research Council would greatly improve both individual scientists' awareness of relevant programmes and the co-ordinated formulation of proposals. Such offices within the Research Council secretariats would provide the vital link between the Councils' Brussels office and their research teams.
- *Support systems*—the support some of the Research Councils give to scientists formulating proposals and pursuing bids for funds appears to be woefully lacking. Researchers particularly require information on timetables and deadlines, the required format for proposals, costing and the criteria applied in Brussels' assessment of bids. At a very practical level, workshops could be instituted for scientists to exchange information and learn from each other.

Memorandum from the University of Salford/CAMPUS

1. I write in response to your letter dated 31 January 1990 inviting written evidence to the above Sub-Committee.

2. My comments will be limited to an Introduction and to your points 1 and 7 which are particularly relevant to relationships between universities and industry.

3 INTRODUCTION

In addition to being Pro-Vice-Chancellor of the University of Salford, I am Director of CAMPUS. Nearly 100 public and private sector organisations are members of CAMPUS and seek to develop links between the University and their organisation. These links cover undergraduate courses, research, continuing education, consultancy and the establishment of small firms. CAMPUS is described in Appendix 1, which includes a list of members, whilst Appendix 2 is the Annual Report for 1988/89 and lists the Trustees. Appendix 3 contains the last two editions of CAMPUS Report which appears 3 times per year and provides information on the links between industry and the University of Salford *(not printed)*.

4. The University has established Salford University Business Services Ltd (SUBSL) which provides consultancy services whilst Salford University Business Enterprises Ltd (SUBEL) has developed the new Business Park at Salford in association with the City of Salford.

5. CAMPUS, SUBSL and SUBEL provide a linked system to encourage and promote innovation.

6. In September 1989, the CBI held a conference on "Nurturing Innovation—making ideas pay". I contributed a paper "Tapping Academia Through Innovation" and a copy of this paper was published in the March 1990 edition of Industry and Higher Education and is enclosed as Appendix 4. This paper provides greater detail of the University of Salford's innovatory activities.

7. RE YOUR Q1: "*What are the effects of company attitudes*"
It is vital that companies have personnel policies which allow and encourage members of their staff to be seconded, full-time or part-time, to universities. Appendix 4 makes the point that interaction between industry and higher education is central to innovation. The Integrated Professor scheme is an important feature of such interactions in which senior staff from industry spend one or two days per week in the University and are fully involved in Departmental Boards and the University Senate which determine policy and allocate resources. Companies can encourage interactions by the appointment of university consultants, the use of the Teaching Company Scheme, joint research projects and in particular the appointment of academics onto the Board of Directors. If professors and senior academics were more involved at Board level in the innovatory process in industry, then their own research would be enriched.

In Appendix 4 the point is made that "Universities have ideas and produce solutions in search of problems and markets. Industry has problems related to design, manufacture or the market and seeks solutions". Personnel policies which encourage and reward individuals who interact with universities would be an effective step in the process of innovation.

8. RE YOUR Q7: "*How effective are the mechanisms for technology transfer from HEIs?*"
Whilst there are mechanisms for technology transfer and these have been effectively used, the Committee should consider the total disincentive to technology transfer which arises from the recent Research Selectivity Exercise and is outlined in Appendix 5. Output from research should be measured not only in terms of peer review assessment of publications in academic journals but also in terms of technology transfer and innovation. Departments involved in technology transfer need to have a soundly financed base of fundamental research. Staff have every incentive to adhere to the rules of the Research Selectivity Ratings game, thus producing a uniform university system. The University system should be diverse with institutions achieving excellence across the range of research activities and outputs. It is as undesirable for Salford to become a second rate Oxford as it is for Oxford to try to become a second rate Salford!

E PARKER
Pro-Vice-Chancellor
Director of CAMPUS
April 1990

Memorandum from Dr C E Webb, University of Oxford

OBSTACLES TO INNOVATION IN MANUFACTURING INDUSTRY, AND THE CONDITIONS WHICH STIMULATE INNOVATION

Perhaps before setting out to answer the Sub-committee's questions in detail I should explain something about my background which may shed light on the nature of my answers.

I am a Reader in the Department of Physics in the University of Oxford and a Senior Research Fellow of Jesus College. Since 1968 I have headed the Gas Laser Research Group in the Clarendon Laboratory. In 1971 my Group achieved a breakthrough in the design of a new type of laser. My colleagues and I tried to interest large UK companies in the possibility of manufacturing and marketing devices based upon this laser design. The response was, to say the least, very disappointing. The only good thing to come out of the experience was the suggestion by Sir Martin Wood that we should set up our own company in order to explore our own technology ourselves. Unfortunately by then a chance had been missed and a German company was well set up and active in the field. However, in 1979 the opportunity arose again where we had developed technology significantly in advance of not only Europe but also the USA. Together with colleagues and my graduate students, I founded Oxford Lasers Ltd. to manufacture and supply equipment based on these designs.

The growth of Oxford Lasers Ltd. since that time has been very satisfying. We have become the world's largest manufacturer of metal vapour lasers and are recognised as leaders in that technology. I am now Chairman of a Company with 60 employees in the UK and a wholly-owned subsidiary, Oxford Lasers Inc., with four employees in the USA. I still continue my full-time University career and pursue research in the Clarendon Laboratory. Our efforts are much aided by the synergy between the Company and the University group. A continuous stream of innovations has been generated, not only by the research group, but now increasingly within the Company, whose research and development team includes many former members of the University Group. Oxford Lasers Ltd. sells not only into the UK and North America but also, *via* a distributor network, throughout the rest of the world. In France and Japan we have had particularly good success. In 1987 we received the Queen's Award for Export, and in 1989 the Queen's Award for Technology. I am a member of the ACOST Standing Committee on international collaboration and have taken a special interest in the EUREKA programme.

In my dual roles as University academic, and Chairman of a manufacturing Company, I therefore have experience of both aspects of invention, transfer of technology, and innovation in industry. It has been often stated in the past that we in Britain are very poor at transferring our good ideas into manufactured products and marketing them successfully. I am convinced that this is true. Unfortunately, traditional British industry has had, until recently, a very poor record of interacting fruitfully with University departments. Our experience of 1971 is just one example. It is a sad fact that my research group is frequently visited (typically twice per year) by trade delegations of up to 20 Japanese industrial scientists. The number of similar visits I get from research scientists in British industry is negligible.

I would also like to point out a fundamental flaw in the organisation of funding for research in Universities in this country, most of which is supported by grants from the SERC. The SERC's committees, particularly those of the Science Board, are dominated by academic scientists representing "pure" rather than "applied" aspects of science. In these days of reduced scientific research budgets, the members of these committees regard expenditure on any topic that could be classified as "applied science" or "technology" as competing with the scarce funds available to support pure science and therefore outside their area of responsibility. With very few exceptions, the Departments of Engineering of UK Universities (unlike their counterparts in the USA and Japan) are concerned mainly with traditional engineering subjects rather than the frontiers of high technology. Members of the SERC's Engineering Board committees drawn for such traditional subject areas almost certainly do not have the necessary background to evaluate applied science or high technology proposals coming from University Departments of Physics.

This would not matter so much if there were a Technology or Applied Science Board within the SERC, but there is not even a Technology Committee within the SERC Science and Engineering Board structure.

There is thus a yawning gap in the support provided by the Research Councils at just the point where support is most needed to carry to full fruition ideas, perhaps one stage removed from absolute novelty, but still lacking demonstration of practical feasibility. Topics which in Japan would be classified as excellent subjects for study in Universities are here denied support because they are no longer "new science" and yet it is out of just such projects that commercially exploitable devices and concepts can grow. The Japanese do not seem so concerned with winning Nobel Prizes. In contrast, we in Britain seem to have developed the attitude that if we can't be first to a scientific breakthrough, then it is best not to try at all. The irony is that even if we do achieve a breakthrough, the "new science" promptly becomes "old science" and no longer worth pursuing, according to the guidelines given to the SERC Committees. In general we in Britain desperately lack the follow-through to the marketplace, a defect which I have tried to remedy by founding my own company.

1. *Effects of company attitudes*

One of the most disappointing features of the insularity of large British companies in their attitude towards taking up new technological ideas, could be exemplified by recent history in the Laser industry. Two British start-up companies, each with a world beating technology and acknowledged leader in their own specialist field, have now been acquired by overseas companies. The first, JK Lasers of Rugby, was initially purchased by Lumonics of Canada, which itself was taken over recently by Sumitomo Industries in Japan. The other, Laser Applications Ltd., started by my colleagues in the University of Hull, has now been taken over by Coherent Inc. of California.

The inventiveness and the innovation that went into starting these companies, and into pioneering the markets that they address, was recognised by overseas companies, but not apparently by any large British company.

2. *How active are UK companies in seeking out external technology?*

In my perception the larger UK companies are not very active in seeking out technology from external sources. This failure to grasp opportunities is surely the result of long years of a "not invented here" mentality in the boardrooms of many of the larger British companies. It is also symptomatic of a rather short-sighted attitude towards investing in research and development of any kind, whether internal or external. It would seem that the financial constraints on internal R&D within large British companies are so severe that the possibility of supporting external R&D simply does not arise. I have had recent correspondence with the Research Directors of six "blue chip" UK companies and, with one exception, all felt that they were doing as much as they could already by way of supporting research in Universities.

3. *Respective roles of product development and production engineering in technological innovation.*

In the context of my own business, product development is concerned with evolving a product that works, and continues to work when it is in the hands of the customer. Production engineering, on the other hand, is the process by which we arrive at a product design that can be built reproducibly and at a cost low enough to enable the company to make worthwhile profit out of selling the product. Both aspects are important. Get either one of them seriously wrong and you will be out of business fairly quickly.

The Japanese have shown that they are willing to invest in long-term product development and production engineering to ensure that the goods they make are reliable and can be profitably sold at a price level that will sell against competition. They are concerned with quality and reliability to the point of fanaticism, as anyone who has sold high-tech products to the Japanese will attest. There is it seems to be a shortage in the UK of suitably qualified engineers to undertake production engineering, especially in the fields of electronics and opto-electronics. We certainly need to encourage more youngsters to take up engineering courses.

4. *Activities of Government departments*

The DTI's LINK programme is making worthwhile progress in promoting collaboration between companies and Universities. Similarly, EUREKA is providing effective support for collaboration in technology between companies in different European countries. Both of these programmes are greatly to be encouraged. However, it is a great pity that the DTI's Support for Innovation programme which preceded the Enterprise Initiative has been terminated. This was, in my opinion, an effective means of bringing new products to the market. There seems to be no replacement programme under which an individual UK company can get assistance to bring a new product to market without being part of a collaboration.

5. *Effects of City attitudes*

Over the past ten years or so the sources of venture capital have increased enormously in numbers and level of funding. Understandably, most of the venture capital funds seek to obtain a very high rate of return on the successful enterprises in which they invest in order to cover losses on unsuccessful ventures. Such investment sources can have an extremely beneficial effect on the start-up companies in which they invest. However, they are usually willing to maintain their investment for a period of 3-5 years at maximum. The driving urgency of such investors to seek an exit route after such a short period (e.g., by finding a purchaser for the company, or via stock market flotation) may not be the best long-term interest of the business and may prejudice its prospects of remaining in UK ownership.

The role of MITI in Japan, with its much longer-term national objectives for research and innovation, finds no counterpart in the UK.

6. *Legislative framework, tax concessions, etc.*

One way of encouraging positive industry/University collaboration would be to provide very strong tax incentives from the Government to industries supporting University research. In recent years Australia has had such a policy where dollars spent by companies on research are matched by an equal input from Government resources.

7. *Mechanisms of technology transfer, role of public laboratories*

The British Technology Group provides an effective service in helping University research and research sponsored by Research Councils to be successfully transferred into manufacturing industry. Clearly this does represent an example of a successful policy.

However, the requirement that the "public laboratories" previously receiving direct Government funding (such as AERE Harwell, and UKAEA Culham Laboratory) should earn a large fraction of their income by undertaking consultancy and sponsored research for industry has put them directly in competition with the Universities. In at least one case this has created a complete breakdown of co-operation in certain areas of research. It is almost an inevitable result of creating an atmosphere of competition that the free flow of information should be stifled. I am not sure it is in the national interest. It seems to me that the old regime, under which one could talk to Government scientists without being charged by the minute, was rather more productive for both sides.

8. *How well does the UK benefit from EC support for innovation?*

The UK does in fact benefit reasonably well from EC support for innovation, but most of this support goes to the larger industries. I think the availability for EC funding has encouraged larger UK companies to display greater enthusiasm for undertaking R&D. However, only a small fraction of the EC funding finds its way into smaller companies and Universities. While big companies can afford to have departments staffed with employees whose sole business it is to write proposals for Brussels and to keep themselves informed about the availability of funding for new projects, very few small companies and Universities can afford such a luxury. Although some attempt has been made to provide representatives of UK Universities in Brussels this provision has not been very effective and I suggest a much more proactive attitude is needed if significant increases in EC funding to the UK Universities and small business sector are to be secured.

9. *Effects of varying relationships between companies and suppliers*

EUREKA has been very selective in forming links between small enterprises in the UK and on the continent of Europe. From my own experience I can say that the EuroLaser Project EU205 has been extremely successful in causing companies in Germany, France and the UK to work together, not least in developing ideas for new products that will address the markets in a sensible and cohesive way. This tendency can only increase after 1992.

10. *Factors influencing decision to invest in innovation in UK or overseas*

I am not sure what factors influence the decision to invest in innovation in the UK or overseas for industry as a whole but, from the perspective of the UK laser industry, I can say that UK laser research and development has a cost effectiveness which is almost unequalled in the world. This is substantiated in a recent report from the Financial Times Business Information Department entitled "Lasers, the Success Story—The Industry in the UK". This report, compiled by Judith Pererra, contains a very good overview of the current status of the UK laser industry. The UK market for lasers and laser systems is estimated to be worth around £51 million per year with output from UK manufacturers now approaching £30 million, over 60 per cent of which is exported. The report concludes that "lasers will become increasingly important in coming years in all sectors where they are used. There is general agreement that Government funding for laser research is dangerously inadequate. Traditionally the UK has been in the forefront of innovations in laser technology, although it has failed to exploit these effectively. There is a widespread feeling in industry, universities, and goverment research institutions, however, that lack of funding is now driving good scientists out of research and into industry and the City. Unless laser research and development receives better support from Government at all levels, there is a danger that the UK could become a secondary market for imported products".

11. *Relationship between defence and civil sectors*

Concerning the role of defence R&D and its relationship with the civilian sector, in my own field there is definite evidence of a slow-down in funding for research supported by Defence laboratories in Universities. There is again evidence that problems concerning ownership of Intellectual Property Rights is providing a real barrier to effective collaboration.

IN SUMMARY

Given that British industrial management takes very little interest in embryonic technologies and that the SERC does not fund projects beyond the first stage of scientific discovery, the only catalyst for products based on new technology is the entrepreneurial spirit of individuals involved in the original scientific research. It is not surprising, therefore, that the rate of innovation is low if we are relying on academic scientists to have the motivation, the financial security, the management skills, and the time to develop the commercial potential of their inventions.

C E WEBB
The Clarendon Laboratory
23 *April* 1990

Letter from Professor J C Willmott, University of Manchester

I enclose a copy of a letter on the subject of Innovation in Manufacturing Industry addressed to Mr David Young of the CVCP, generated by Professor M Gibbons and myself. I believe the points we make are valid, and that is why I am sending you a copy direct, but I would also like to amplify our point number one.

There is, I believe a fundamental difference between Scientists and Engineers on one hand and people trained in the Arts and Humanities on the other. Scientists and Engineers are concerned with extending, developing and applying a body of knowledge in a quantitative manner, whereas students of the Arts and Humanities are more concerned with taking an established body of knowledge and attempting to persuade people to look at it from a new point of view. This latter activity is a qualitative rather than a quantitative one, and further, is the stuff of politics; thus a good arts graduate is almost immediately ready to be trained in Civil Service ways and methods. Whereas, because of the quantitative aspect of science and engineering a graduate needs a further 5-10 years of experience before he or she is truly able to make this distinctive contribution, and this experience cannot be gained in the Civil Service. As a result I believe the Civil Service does not really know how to use scientists and engineers.

The above is obviously something of an over simplification, but my experience with foreign academics who work within frameworks that allow more easily to transfer between activities, what the Americans call "Inners and Outers" suggests to me that there can be considerable benefits to the system as a whole where this sort of activity occurs more easily. It necessarily means that there has to be greater parity than at present between Civil Service salaries and those of academics, but if a suitable framework could be established I believe that not only would it benefit the Civil Service and academia, but also allow a better academic/industrial interchange and possibly even a Civil Service/industry interchange. We are too compartmentalised.

J C WILLMOTT
Advisor to the Vice-Chancellor on Research Exploitation
17 *April* 1990

Letter from Professor M Gibbons and Professor J C Wilmott

The Vice-Chancellor has asked us to prepare a response to the House of Lords Select Committee on Science and Technology in connection with its forthcoming inquiry into "Innovation in Manufacturing Industry". We are in the course of preparing that document now and will send you a copy as soon as we have completed our task.

In your letter of the 2 February 1990, you also asked for advice from the University about how the CVCP should respond to this Lord's Committee. In preparing this, we suggest you pay attention to the following points:

1. The mere existence of the sub-committee implies their Lordships suspect that all is not well in manufacturing industry; yet, none of their questions address the fundamental problem of British Manufacturing Industry. This is that the low status of scientists and engineers in this country does not encourage them to be innovative, and the best ones leave (if they ever go into industry). After two years the pay of an accountant would employ a physicist and school teacher.

The force of this argument may be seen by looking at the fine chemicals and pharmaceutical industry where scientists and engineers are well rewarded.

2. Innovation is, except in very exceptional cases, time consuming. Who in manufacturing industry is interested in long-term rewards?

3. International competitiveness is forcing firms to make increasingly sophisticated products for specialised markets. As a result industrial managers must be familiar with automated, computerised, flexible manufacturing systems. Are they, and are they aware of what universities can offer in the fields of advanced manufacturing technology, systems engineering, control systems, etc?

4. The Committee will be interested in changes in the universities since the BTG monopoly was broken. The technology transfer mechanisms in universities still suffer because (a) the university authorities do not always realise that technology transfer cannot be done on the cheap and (b) that the investment horizon of venture capitalists is very short. It is difficult to make the transition from the working idea in the university to the robust prototype that will interest a firm. Universities by themselves do not have enough resources and neither venture capitalists nor industrial firms seem to want to be involved at a reasonably early stage of development.

5. Finally, you might suggest that the Committee look at technology transfer from the universities arising out of the increasing number of collaborative projects with industry (e.g., Alvey, the Link initiatives, teaching company schemes, etc.). For our part, we will certainly be commenting on the detrimental effects on collaboration and subsequent technology transfer of aggressive postures on intellectual property held by some firms and a few government departments. Somehow, we have got to get it across that the intellectual resources available to industry by the university system are products of many years of investments by the universities—investments which may run into tens if not hundreds of millions of pounds over a ten year period—and that paying for a piece of contract research does not automatically convey complete ownership to the results of research. Many firms appreciate this point and are quite prepared to, for example, enter into an exploitation agreement with the university and give us some share in the sales that might arise if exploitation were undertaken. The Lord's Committee appear to be interested in attitudes that block as well as those that promote innovation. Intellectual property disputes are a block on technology transfer in that they often sour relationships and discourage a spirit of openness in collaborations.

We hope that you find these comments helpful. If we can be of any further assistance to you please do not hesitate to contact us.

Professor J C WILLMOTT
Advisor to the Vice-Chancellor on Research Exploitation

Professor M GIBBONS
Director
Research and Technology Transfer Office
1 *March* 1990

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